SEVENTEENTH YEAR OF PUBLICATION.

THE

JOURNAL OF SCIENCE,

AND ANNALS OF

ASTRONOMY, BIOLOGY, GEOLOGY, INDUSTRIAL ARTS, MANUFACTURES, AND TECHNOLOGY.

(MONTHLY, FORMERLY "THE QUARTERLY JOURNAL OF SCIENCE.")

Vol. II. (THIRD SERIES)
No. LXXIX.

JULY
1880.

CONTENTS.

ARTICLES.	PAGE
1. The Evolution of Scientific Knowledge. By C. LLOYD MORGAN	415
2. Habits and Anatomy of the Honey-bearing Ant. By C. MORRIS	430
3. The "Laws of Emphasis and Symmetry." By J. W. SLATER	434
4. Instinct and Mind. By S. BILLING	438
5. Tuberculosis transmissible through the Meat and Milk of Animals affected with it ..	441
6. Natural Science and Morality. By S. TOLVER PRESTON ..	443

ANALYSES OF BOOKS.	PAGE
Catalogue of Books and Papers relating to Electricity, Magnetism, the Electric Telegraph, &c.	463
Heat, a Mode of Motion	464
Degeneration	465
Letter of the Commissioner of Agriculture on Sorghum Sugar	467
Alphabetical Manual of Blowpipe Analysis, showing all Known Methods, Old and New	468
Journal of the Society of Telegraph Engineers	469
Astronomical Observations made at the Melbourne Observatory	470
The American Naturalist	470
CORRESPONDENCE. NOTES.	

LONDON:

3, HORSE-SHOE COURT, LUDGATE HILL.

Where Communications for the Editor and Books for Review may be addressed.

PRICE ONE SHILLING AND SIXPENCE.

[*The Articles and Reports in this Journal are Copyright.*]

BROWNING'S BINOCULARS.

OPEN.

CLOSED.

THE NEW PORTABLE BINOCULAR.

This is the most efficient contrivance yet produced for making a Binocular, Field, or Opera-glass portable without any sacrifice of efficiency, and it is much less liable to injury when made portable than any Binocular of the ordinary construction, as in this form the instrument is so hardy that it may be sat upon without the least risk of injury.

The object-glasses of this Binocular are 1¼ inches in diameter, and when the instrument is closed it forms a tube 4 inches long and 1⅜ inches diameter. The mountings of the instrument are all strongly nickelised, and will not tarnish, and the workmanship is of the best kind.

The Engravings show the instrument both open and closed.

Price of the Instrument, covered with Russia, complete in case.. £1 12 6

Sent packed and carriage paid, for 1s. 6d. extra.

ILLUSTRATED CATALOGUE SENT FREE.

JOHN BROWNING,

Optical Instrument Maker to H.M. Government, the Royal Observatory,

63, STRAND. LONDON, W.C.

THE CHEMICAL NEWS

Edited by WILLIAM CROOKES, F.R.S., &c.

Published Weekly, price 4d. Annual Subscription, £1, payable in advance.

This Journal is devoted to Scientific and Applied Chemistry, and also embraces whatever tends to elucidate new discoveries in Mineralogy, Metallurgy, Mining, Mechanics, Electricity, and the collateral branches of Physical Science. It also contains an encyclopædic list of chemical papers published abroad during the previous week, with abstracts of all susceptible of advantageous abridgment, thus making the two half-yearly volumes, with their copious indices, equivalent to an English edition of the "Jahresberichte."

LONDON: BOY COURT, LUDGATE HILL, E.C.

RS.

R.
nocular,
nd it is
of the
may be

d when
iameter.
tarnish,

12 6

ory,

W S

dvance.

whatever
ectricity,
ic list of
sceptible
copious

XUM

JO

IN

of E
Of t
ago,
than
and
perti
defin
thou
Evo
gene
tion,
diffe
cess
beco
sam
bour
as in
diffe
whic
the
gina
case
mot
diffe
vo

XUM

THE

JOURNAL OF SCIENCE.

JULY, 1880.

I. THE EVOLUTION OF SCIENTIFIC KNOWLEDGE.

By C. Lloyd Morgan.

IN the "Westminster Review" for April, 1857, appeared an Essay on "Progress: its Law and Cause," by Mr. Herbert Spencer, in which was first sketched the *Law of Evolution* more fully developed in the First Principles. Of that law the late Prof. Clifford said, some twelve years ago, that "it is to the ideas which preceded it even more than the theory of gravitation was to the guesses of Hooke and the facts of Kepler." And now it seems almost an impertinence to the reader to occupy any space here with a definition of this Law of Evolution. Still, impertinence though it be, I venture to preface what I have to say on the Evolution of Scientific Knowledge with a few words on the general law, by way of reminder. The processes of Evolution, according to Mr. Herbert Spencer, are processes of *differentiation* and *integration;* that is to say, they are processes by which the parts of that which is being evolved become more *different*, and by which those parts, at the same time, become more *dependent upon each other*, and are bound together into a more *definite, complex whole*. Where, as in most cases, Evolution is accompanied by growth, the differentiation and integration are not confined to the parts which originally existed in the system, but are extended to the material which is gradually incorporated with the original matter. And where, as is always more or less the case, the parts of the evolving system are in motion, this motion also is subject to the processes of integration and differentiation.

A hypothetical example of the simplest possible kind will not here be out of place. Take a tribe of savages in the pre-social stage. Each individual does for himself all that he wants done: he cuts his own bow, makes his own arrows, and shoots for himself the wild creatures from which he has himself to prepare food, and perhaps clothing. Now let Evolution come into play. Differentiation sets in. There is an incipient division of labour. One individual devotes himself to the making of bows and arrows on the understanding that they whom he supplies shall procure him food and clothing; another dresses the food or the skins on similar terms; and so on. It is needless to elaborate this example; for without elaboration it is clear that the individuals of a tribe so far evolved have become more different, and at the same time more dependent on each other; while the tribe itself has been converted into a more definite, complex whole.

Such being, therefore, the law of Evolution, I propose in this paper to apply it to the history of Science. I shall endeavour to show that the advance in complexity, definiteness, and integration, which constitutes Evolution, is seen not less clearly in our *knowledge of phenomena* than in the phenomena themselves. It matters not, I believe, to which branch of Science we turn our attention; all tell the same tale. Definiteness of observation, complexity of subject matter, interdependence of phenomena, comprehensiveness of generalisation—all these advance hand in hand. The history of science is the history of an evolution, and the Law of Evolution is the outcome of that evolution.

At the outset, however, an objection may be raised to this application of a physical law to the products and processes of the mind. And to those who see no connection between consciousness and the vibration of brain-molecules, who recognise no physical basis of mind, the objection is probably insuperable. But while the fact cannot be too frequently insisted upon, that we are utterly and completely unable to conceive *how* the vibrations, decompositions, or isomeric changes of grey nitrogenous matter may be accompanied by the phenomena of conscious thought; while we must honestly confess that this is, and probably ever must be, an inscrutable mystery; still we seem forced, by the balance of scientific evidence, to infer that there *does* exist a definite connection between what we characteristically call *brain power* and thought. And if this be so, then it is evident that the evolution of scientific knowledge is but the sign of the evolution of one portion of the individual and social organisation.

For just as the varying sound of the voice from feeble treble to resonant bass testifies to the gradual development of the vocal organs, so does the evolution of scientific knowledge testify to the evolution of the brain power and brain complexity of which that knowledge is one of the products.

Before we proceed to the consideration of some special instances of this evolution as exemplified by the sciences of astronomy, geology, and chemistry, it will be well to devote a short space to the broader question, From what has Science in general been evolved? To this question there can, I think, be but one answer. The more or less organised knowledge which we call Science has sprung from the unorganised general knowledge of our uncultured ancestors. In an Essay on the "Genesis of Science" Mr. Herbert Spencer has treated this subject with masterly clearness. The first step towards knowledge of any kind is classification; and classification is based on the recognition of likeness and unlikeness. We only know an object when we recognise that it is like something we have before met with. If it be like nothing that we have before seen or heard of, we say that we do not know what it is. And just as classification is the grouping together of like things, so is reasoning the grouping together of like relations among things. Now it is by the extension of these processes of grouping together like things and like relations among things that Science arises. But so far the science is only *qualitative*. It is only when the recognition of *likeness* grows into the recognition of *equality* that science becomes quantitative; for equality—equality between things and equality between relations—is the fundamental conception which underlies all mathematics. Out of this conception of equality therefore springs *exact science*, endowed with the power of quantitative prevision. We may, in fact, from one point of view, divide Science into three stages—that of merely qualitative prevision, that of vaguely quantitative prevision, and that of exact quantitative prevision. Let us take an example of each. From a study of the appearance of the sky, and from observations of the barometer and hygrometer, I may be able to foretell a storm; but my prediction cannot be in any sense quantitative, for the storm may last a couple of hours or continue for as many days. After careful diagnosis the skilful physician knows that the administration of a certain drug will have a certain effect upon his patient; but his prevision is only vaguely, not exactly, quantitative. On the other hand, after taking into consideration certain perturbations of the planetary system, M. Leverrier, in 1846, inferred the presence

of a hitherto unrecognised planet, and recommended M. Galli, of the Berlin Observatory, to direct his telescope, on the 23rd September, to a definite point in the heavens: he did so, and beheld the planet Neptune. Here, then, was exact quantitative prevision. In the last of these examples we see science *completely* differentiated from common knowledge. In the first we see science *scarcely* differentiated from common knowledge. The child who having been burnt dreads fire exhibits qualitative prevision, but it can scarcely be said that his knowledge is science. And this serves to show how difficult it is to separate common knowledge from incipient science. Looking at the question then in this general way, there can, I think, be no doubt that the passage of the general mass of knowledge into science exemplifies evolution. In the separation of the special sciences from each other we have a clear case of differentiation; in the growing inter-dependencies of the sciences (to be more particularly noticed presently) we have a further trait of evolution; while daily integrations of our knowledge tend more completely to fuse the body of scientific knowledge into a definite complex whole.

Let us now turn to more special examples.

It is probable that in very early times men were led to speculate on the constitution of that starry firmament which night after night met their gaze. What may have been the exact nature of the views which were the outcome of this primitive guessing we shall probably never know, but we may form some idea by enquiring what are the views of the uncivilised to-day. We find, on doing so, that the South Australians think "the constellations are groups of children," and "three stars in one of the constellations are said to have been formerly on the earth: one is the man, another his wife, and the smaller one their dog; and their employment is that of hunting opossums through the sky." We find, too, that the Esquimaux think the sun, moon, and stars are "spirits of departed Esquimaux, or of some of the lower animals." We find again—but we need go no further. Little is to be learnt from these guesses; but we may fairly suppose that it was long ere vague mythological ideas gave place to conceptions based on physical analogies. Among the early Greeks, however, the phenomena of the heavens were, according to Whewell, explained on the supposition that the sky is a concave sphere or dome, to which the stars are fixed, and that the celestial sphere revolves perpetually and uniformly about the pole or fixed point. Here, then, we have an explanation in some sort physical, but one of

extreme simplicity and generality, and one, therefore, which exemplifies an early stage in evolution. But ere long this simplicity gave way to incipient complexity. To account for the way in which the appearances of different nights succeed each other, the sun also was supposed to move round among the stars on the surface of the concave sphere; and, if we are to believe Pliny, Anaximander was the first to point out that the circle in which the sun moves is oblique to the circles in which the stars move about the poles. Other irregularities were in process of time discovered, and the celestial mechanism by which they were explained grew proportionally in complexity. The wandering planets changed their course, moving now forwards and now backwards; and to account for this motion each was supposed to be placed on the rim of an invisible wheel, which revolves on its centre while it moves around the sphere. Such a wheel was called an epicycle. Then it was discovered that the motions of the sun and moon also were irregular, so that they too were placed on the rims of imaginary epicycles; while it was found that, for purposes of calculation, the same results were reached if—abandoning the epicycle—the sun were supposed to revolve in a circular orbit in which the earth does not occupy a central position, but is placed rather nearer to one side. Such an orbit was called an eccentric. Finally, as further anomalies and irregularities were discovered in the motions of the sun, moon, and planets, further extensions of the hypothesis of eccentrics and epicycles were rendered necessary until the master-mind of Hipparchus formulated and organised this system, the essence of which consists in the resolution of the apparently regular motions of the heavenly bodies into an assemblage of circular and uniform motions.

In those days, it must be remembered, circular motions were the only motions admissible; the idea of "such disorder among divine and eternal things as that they should sometimes move quicker, and sometimes slower, and sometimes stand still," was considered impious, "for no one," it was said, "would tolerate such anomaly in the movements even of a man who was decent and orderly." And thus there sprang up that complex system which gave rise to the celebrated saying of Alphonso X., of Castille, that "if God had consulted him at the creation, the universe should have been on a better and simpler plan."

That the history of early astronomic thought above sketched exhibits an advance from the vague to the definite, and from the simple to the complex, while it shows also an

increase in integration and dependence of parts, cannot, I think, be for a moment doubted. And the views of Hipparchus, as developed by Ptolemy, may perhaps be looked upon as the culmination of the evolution of the geocentric idea, while the later history of Astronomy exhibits the evolution of the heliocentric idea.

A scientific theory in some respects resembles an organism, and especially in this—that it must harmonise with its environment or die. The environment of theory is fact. So long as a theory is in harmony with the known facts of Nature it can exist, the development of a theory being its modification in accordance with newly-discovered facts. But when the plasticity of a theory ceases,—when it refuses to accommodate itself to fact,—its days are numbered, and it must give place to a more fortunate rival in the struggle for existence. In this way the Earth-centre theory of our system, organised by Hipparchus and developed by Ptolemy, had to give place to the Sun-centre theory, foreshadowed by Pythagoras and worked out by Copernicus. As Whewell truly remarks, so long as the *positions* only of the heavenly bodies were considered, the hypothesis of Hipparchus is a close representation of the truth; but when once the processes of measurement gave sufficiently accurate results with respect to the *distances* of these bodies, the theory and the environing facts were out of harmony, and the theory was doomed. And when Galileo discovered, with the newly-invented telescope, in the system of Jupiter and his moons, a model of the Solar System; when he found that Venus, in the course of her revolution, assumes the same succession of phases which the moon exhibits in the course of a month; and when Kepler observed the transit of Mercury, and Horrox the transit of Venus; then the fate of the old hypothesis was sealed, and the success of the new theory was secured.

Copernicus, however, retained the conception of circular motion, and the consequent existence of epicycles. But the idea of epicycles, like the geocentric idea, ere long ceased to be in harmony with the environment of fact. Kepler, we are told, attempted to reconcile the theory of Mars to the theory of eccentrics and epicycles, the event of which was the complete overthrow of that hypothesis, and the proposition in its stead of the theory the central truth of which has long since been abundantly established, that the planets move in ellipses. And this, be it noted, was a substitution of a more complex and integrated kind of motion for a combination of more simple kinds of motion.

As we now know, indeed, the motion substituted is even more complicated than Kepler supposed. For not only does the ellipse itself revolve slowly round the sun, but its shape undergoes change, being sometimes more nearly circular than at others, while, at the same time, the plane of the planet's motion oscillates about a mean position. Thus it comes about that the ellipse which accurately represents the planet's motion at one part of its course does not accurately represent that motion at another part of its course.

But the indefatigable industry of Kepler, besides establishing the elliptical theory, led him to the discovery of two other fundamental laws of formal astronomy,—that the line drawn from sun to planet sweeps over equal areas in equal times; and that the square of the time taken to describe a planet's orbit, divided by the cube of its mean distance from the sun, is a fraction which is the same for every planet of the system. And these formed the bases for the grand generalisation which was inevitably to follow.

For the next great step in astronomy was Newton's splendid induction. So gigantic was the onward stride then made—a stride without parallel in the history of Science—that it seems at first sight impossible to reconcile it with the gradual advance implied in a development by Evolution.

But a closer study of history makes evident the parallel but imperfect generalisations which were simultaneous with this more perfect and exact generalisation. While Newton at Oxford was pondering on cosmical gravitation, Borelli in Florence was publishing his theory of the "balancing of the planets," arising, as he conjectured, from the equality of an "appetite for uniting themselves with the globe round which they revolve," and the "tendency to recede from the centre of revolution." While Newton was preparing his "Principia," Huyghens, Wren, Halley, and others seem to have possessed a general idea that the attractive force exercised by the sun varies inversely as the square of the distance from the centre. Hooke even went so far as to claim priority in publication to Newton himself. And it is undoubtedly true, as Whewell points out, that Hooke's *assertion* was prior to Newton's demonstration. Francis Bacon, again, had not only speculated on the mutual attraction of the particles of matter, but devised an experiment to ascertain "whether the gravity of bodies to the earth arose from an attraction of the parts of matter towards each other, or was a tendency towards the centre of the earth." But these were but foreshadowings of the truth. It remained for Newton to demonstrate that the same law—that the attraction is directly as

the joint mass of the attracting and attracted bodies, and inversely as the square of their distance asunder—holds good for the sun's attractive influence on different planets and on the same planet in different parts of its orbit; for the earth's attractive influence on the moon, and on bodies near the earth's surface; for the mutual attraction of sun, moon, earth, planets, and satellites on each other; and for the attractions of the individual particles of which these masses are composed.

The bearing of these well-known facts on the theory of Evolution will now be evident. Not only does the conception of Universal Gravitation exhibit a great advance in the ideas of the inter-dependence of the members of the solar system,--not only does it show an onward stride in the integration of our knowledge, but it displays also a vast increase in the orderly complexity of our views of that system by introducing definite conceptions of matter and force in addition to those of motion and distance. And here we might well leave the history of Astronomy, satisfied that it has afforded ample illustration of the law under consideration. But for the sake of rounding off the argument attention may be drawn to the advance in the traits which characterise evolution implied in the nebular hypothesis of Kant and Laplace, which affords a not improbable conception of the mode of development of our system, and implied also in the results of modern spectroscopic researches, which teach us that the chemistry of the sun and stars is not dissimilar to the chemistry of the earth, and which have raised the physics of the sun to the rank of an independent science. When we take into consideration, too, the conceptions concerning stellar distribution, started by Wright, developed by William Herschel, and now criticised and opposed by Proctor, and add to these the results concerning the motion of the sun through space, the velocities of motion of certain stars determined by Huggins, and the "drifting" of star groups inferred by Proctor, we shall not lack instances of advance in definiteness of knowledge, in inter-dependence of ideas, and in complexity of our total conception of the phenomena of the heavens; while the labours of Schiaporelli, Huggins, Donati, Lockyer, and Sir William Thomson, the results of which point to an intimate connection between nebulæ, comets, meteorites, and falling stars, bring into view a proportionate advance in the integration of that knowledge.

If now we pass from our knowledge of the solar and sidereal system to that of the crust of the earth, we shall find many facts which point clearly in the same direction.

A few of these may be noticed. When Lister, in 1683, proposed to the Royal Society that maps of the soils and minerals of England should be made, he probably was not aware of the existence of continuous layers of rock or *strata*. It was perhaps Hooke who first conceived the idea of "*raising a chronology*" out of the records of the rocks, while to Woodward has been attributed the earliest definite enunciation of the continuity of strata. We shall not therefore be far wrong in saying that, previously to the middle of the seventeenth century, the prevalent ideas of the structure of the earth's crust were altogether general, disconnected, and indefinite. From such views have been evolved, by gradual stages, the special, connected, and definite conceptions of modern geologists; for whatever may be said of geological theory, there can be no doubt that the tabulation of British strata may be thus characterised. And it is only necessary to point to the recently-established connection between sedimentary, metamorphic, plutonic, and volcanic rocks, to show clearly the marked integration which has gone on in our knowledge of the crust of the earth. Nor do we find a different result when we turn from descriptive geology to causal geology. Although Ray, in 1692, "enlarged upon the effects of running water upon the land, and of the encroachment of the sea upon the shores," yet when Buffon, half a century later, maintained that "the waters of the sea have produced the mountains and valleys of the land," his attempts at a natural explanation of the origin of the features of the earth were so far out of harmony with the accepted tenets of his age that he was politely requested, by the Faculty of Theology in Paris, to recant. When now we contrast the total ignorance of, or the wilful blindness to, the action of natural causes implied by this act, with the view generally accepted to-day, owing to the strenuous advocacy of Hutton and Lyell and their successors, that every feature of the earth's surface, and every record buried in the rocks, is the result of causes similar in the main to those now in action,—when we compare the views of Woodward or Whiston (dealing as they do with universal deluges and comet-tails) with the views of Ramsay or of Judd,—we shall not fail to see a marked advance in all those special traits which characterise evolution. And now the broad generalisation that, with trifling exceptions, all geological action is due to the antagonism of sun-heat and earth-heat shows an integration of knowledge that can scarcely be carried further.

If now we turn from the history of our knowledge of the

earth's crust to the history of our knowledge concerning the constitution of the matter of which that crust is composed, we shall obtain further exemplification of the Law of Evolution. Among the early Greeks we find prevalent the doctrine of the four elements, Earth, Water, Air or Steam, and Fire, of which all bodies were supposed to be composed. But, as Dr. Roscoe points out, these terms denoted rather general properties than particular substances. "Thus earth implied the properties of dryness and coldness; water, those of coldness and wetness; air or steam, wetness and heat; fire, dryness and heat. All matter was, indeed, supposed to be of one kind, the variety which we observe being accounted for by the greater or less abundance of these four *conditions*." Here, then, we have a theory which is sufficiently vague, general, and indefinite. Somewhat similar, but more advanced, are the views of the Arabian alchemist, Geber, according to whom "the essential differences between the metals are due to the preponderance of one of two principles, mercury and sulphur; of which all the metals are composed." According to him "the noble metals contained a very pure mercury, and were therefore unalterable by heat, whilst the base metals contained so much sulphur that they lost their metallic properties in the fire." To these two principles Basil Valentine subsequently added a third, which he called Salt: while Lemery, calling these the active principles, added two more, which he termed passive, namely, water or phlegm and earth. The first philosopher, however, who seems to have grasped the idea of the distinction between an elementary and a compound body, was Robert Boyle; and this conception cannot but be regarded as an immense advance in descriptive chemistry. But the theory which had the most marked influence on the history of chemistry in the seventeenth century was that which was started by Becher and developed by Stahl, and which is known as the Phlogistic theory. When magnesium wire is burnt in the air a white solid is formed. We now know that this is the result of the combination of the metal with the oxygen of the air; but, according to the Phlogistic theory, this white substance results from the fact that the metal has lost a "combustible principle" which Stahl termed *phlogiston*. It was upon this hypothesis that Black, Priestley, and Cavendish—the founders of exact chemical science—worked, and it was their labours which afforded the observations which resulted in the complete overthrow of that theory. For the Phlogistic hypothesis, like the geocentric conception of the Solar System, was ere long found

to be out of harmony with the facts, and was therefore worsted in the struggle for the Survival of the Fittest. It was found that chemical substances during combustion, instead of losing weight by the abstraction of phlogiston, gained in weight, the products of combustion being heavier than the body burnt. It was in vain to try and "bolster up the old theory" by the hypothesis that phlogiston is so light in its nature that it makes the bodies with which it combines lighter than they were before, though this view seems seriously to have been entertained. When Lavoisier found that mercury, on being heated for a long time in the air, absorbed oxygen and increased in weight, and that when the material formed was subsequently heated it lost weight and gave up just so much oxygen as it had before absorbed, the Phlogiston theory was doomed, and the science of chemistry was placed on its true basis; while at the same time, and by the same man, the foundation of quantitative chemistry was laid by the distinct assertion of the indestructibility of matter.

But we cannot say that a true quantitative theory of the chemical constitution of matter was in existence before Dalton, in 1803, published his first table of atomic weights, and showed "that elements combine in *definite* proportions; that these determining proportions operate reciprocally; and that when, between the same elements, several combining proportions occur, they are related as multiples." This conception of definite combination by *weight*, which has been termed "the pole star round which all other chemical phenomena revolve," was not long afterwards supplemented by Gay-Lussac's law of definite combination by *volume*, which received an explanation in 1811 at the hands of Avogadro, who assumed that equal volumes of all substances, when in the state of gas and under like conditions, contain the same number of molecules,—an hypothesis which is borne out independently by both chemical and physical considerations.

When we add to the advances in chemical science already noticed Sir Humphry Davy's discovery of the compound nature of the alkalies; the determination, by Dulong and Petit, that the atoms of many of the elements have the same capacity for heat; the proof, by Berzelius, that organic bodies obey the same laws as inorganic substances; followed by the artificial production, by Wöhler, of urea, a material before supposed to be exclusively the product of life: when we consider the overthrow of the dualistic theory, that salts result from the union of an acid oxide with a basic oxide,

by the modern view that they result from the displacement of the hydrogen in an acid by a metallic or other radical; and when the reader is reminded of the advances implied in the terms atomicity, isomorphism, allotropy, isomerism, diffusion, dialysis, crystalloid and colloid, and many others, he will admit that, though chemical science yet awaits its Newton, it exemplifies a continuous advance in definiteness, dependence of parts, orderly complexity, and integration.

Without staying to point out that our knowledge of the physical constitution of matter exemplifies evolution not less clearly than that of the chemical constitution of matter, attention may now be very briefly drawn to the conceptions of Force. To illustrate the indistinctness of ideas on this subject which prevailed in comparatively early times, I may give a quotation from Pliny, cited by Whewell:—"What," he cries, "is more violent than the sea and the winds? what a greater work of art than a ship? yet one little fish (the *Echineis*) can hold back all these when they strain the same way. The winds may blow, the waves may rage; but this small creature controls their fury, and stops a vessel when chains and an anchor would not hold it; and this it does not by hard labour, but merely by adhering to it." "In our own memory," he continues, "one of these animals held fast the ship of Caius, the Emperor, when he was sailing from Astura to Antium." Now although it may be objected that the Greeks, long before Pliny wrote, had some definite mechanical notions, and that this quotation gives an over-estimate of the amount of indefiniteness of early knowledge on this subject, still the fact remains that so indefinite was this knowledge before the time of Galileo that the first law of motion—that a moving body, if entirely left to itself, will continue moving in the same direction and with the same velocity—had not been distinctly grasped. And even when this highly abstract law *was* at length grasped,—when it was seen that under ordinary circumstances (on our earth, for example) the onward motion of a body is stopped by the resistance afforded by the air, or by solid or liquid bodies,—even then for a long time no account was taken of the motion thus apparently lost; and it was reserved for modern times to show that the force which this motion implies is not destroyed by the resistance, but only takes on a new form in the molecular motion of heat, developed in the resisting and resisted bodies. And this conversion of the motion of a mass of matter into molecular motion was subsequently found to be only a particular instance of the conservation of energy, the discovery of

which law, considered as it is by some the chief glory of modern science, exemplifies clearly the results of an evolution. As a quantitative law it has increased the definiteness of our knowledge; as a generalisation which comprehends *all* forms of energy, it has increased the integration of our knowledge; and, implying as it does the transformations of the various forms of energy into each other, it exemplifies also an increase in dependence and orderly harmony.

Having now given some examples of the evolution of certain branches of scientific knowledge (lack of space precluding further exemplification from the biological, sociological, and psychological sciences), the fact must be pointed out that in no case is the evolution of one branch of such knowledge independent of the evolution of other branches. The term *branch*, indeed, suggests the conception of a general tree of knowledge of which they are the offshoots. But the special sciences might perhaps be more profitably likened to the organs of the animal organism. For not only do the several organs progress together with the progress of the whole of which they are the parts, but each organ ministers in its own fashion to the welfare of the whole and of the other organs. Mr. Herbert Spencer has given many examples of the dependence of the advance of one branch of science upon the advance of other branches. It is therefore unnecessary here to do more than indicate the nature of the evidence. Where would Astronomy be now, it may be asked, without the advance in Optics implied in achromatic telescopes; without the discoveries in Mechanics of the laws of motion, and of the anachronism of the pendulum; without the determination of the specific gravity of the earth, and the measurement of a degree on the earth's surface? There is indeed scarcely a branch of Science upon which Astronomy does not call for aid. In addition to those just mentioned she relies on Atmospheric Physics for tables of atmospheric refraction; upon Chemistry for photographic processes; upon Electricity for various recording instruments; and upon Psychology for the personal equation,—the time which elapses between seeing and registering which varies in different individuals. These facts are sufficient to exemplify the inter-dependence of the sciences, and they form not a tithe of the number which could be adduced. We have only to trace the interaction of terrestrial and astronomical physics on Mathematics, to watch how new problems in physics called forth new mathematical processes, which processes enabled further physical advance, and thus led to fresh problems; we have only to consider

how Chemistry has aided electrical science, and been aided in turn by that science; we have only to observe how Geology has profited by the advance of Biology, and at the same time has aided in solving important biological problems; we have only, in a word, to study the history of Science in a scientific spirit, to see how completely the organs of the body scientific are dependent on each other, and are bound together into a definite complex whole.

Let it then be clearly noted that the advance in scientific knowledge is not merely, as some suppose, an increase of the mass of accumulated facts. It is this, but it is much more besides. Just as the more extended view which the mountaineer obtains as he rises above the valley does not charm so much by the multiplicity of objects as by the connection which is disclosed among them, so, too, the more extended view which the philosopher obtains, as he climbs the hill of Science, does not owe its value so much to the number of facts accumulated as to their definite organisation.

In conclusion, one or two general facts may be pointed out. There is no more striking trait in the evolution of knowledge than the fact that not unfrequently the same discovery is made almost simultaneously by different workers labouring altogether independently of each other. Instance the theory of Natural Selection elaborated simultaneously by Darwin and Wallace; instance, again, the independent liquefaction of oxygen by MM. Pictet and Cailletet. Or again, perhaps, we find that the same law or theory is advanced by several men as a speculation, and by one master mind as a demonstration. This may be said to have been the case in the discovery of the Law of Universal Gravitation. Now these facts are in full accordance with the theory that the development of our knowledge is an evolution. When the environment of ascertained fact has reached a certain definite state, its influence inevitably calls forth the development of a new theory which shall be in harmony with all the conditions. In the minds of Newton's contemporaries the environment of accumulated facts called forth general conceptions more or less in harmony with these facts; but in the master mind of Newton not only was the environment of fact more extended, from his powerful grasp of intellect, —not only was that environment more pressing, from his constant habit of earnest thought,—but the conceptions were more definite, from the extraordinary depth of his mathematical insight. The result was the production of a law and a book which have been the wonder of all after-time.

Newton's contemporaries were at a high enough level of thought to accept his generalisation, which thereupon became part of the environment which induced subsequent though minor generalisations. But this has not always been so. Sometimes the conception of a master mind has fallen amid conceptions having so little in common with it, that its influence has not been felt until the subsequent advances of knowledge have caused its re-development, and called the attention of the world to a genius who lived before his time. Such was the case with some of the generalisations of Archimedes, and of Roger Bacon, to mention no other names.

Finally, we may notice the fact that just as in the organic world we have the highly organised human being existing side by side with the lowly organised *entozoon*, so too we have, in the world of thought, conceptions in some sort in harmony with the grandeur of the Cosmos side by side with conceptions moulded to the meanest and most trivial facts. But there is nothing here at variance with the theory of Evolution. The human being and the entozoon are each more or less in harmony with their several environments, and any advance in the development of each is such as to bring it more clearly in harmony with all the conditions. So, too, the conceptions of the philosopher and the clown are each more or less in harmony with the environing facts by which they are respectively surrounded; and here too, in each case, any advance in development is such as to bring the conceptions more closely in harmony with the surrounding facts.

To this parallel between the organic world and the world of thought we may add another. It is now generally admitted that the evolution of the individual is a condensed epitome of the evolution of the species to which that individual belongs. The evolution, for example, of an individual frog from the undifferentiated egg to the complex adult epitomises the evolution, through long ages, of frogs from simpler forms of life. So, too, does the evolution of the conceptions of the individual philosopher epitomise the evolution of philosophic thought in general. Both in the individual and in the race the discovery of law is itself subject to law, and, if there be any truth in the views above advocated, the law to which it is subject is the Law of Evolution.

II. HABITS AND ANATOMY OF THE HONEY-BEARING ANT.

By CHARLES MORRIS.

IN the February number of the "Journal of Science" were published certain results of Dr. McCook's investigations on the habits of the honey-bearing ants. Since the period in which these observations were made he has had under his constant supervision an artificial formicary of these ants, and has made some further interesting communications in regard to them, of which the following is a condensed sketch.

The most striking points of these communications relate to two particulars, one bearing on the sympathy, or spirit of beneficence, in the ants; the other relating to their anatomy. The first of these particulars is in the same line of research as that followed by Sir John Lubbock, in his observations on the behaviour of ants towards captive friends and enemies, in which he discovered that, while the ants were full of hostility against individual foes, they showed no evidence of sympathy for friends in trouble.

Dr. McCook's observations lead to the same result. In making his artificial formicaries he simply pressed a quantity of earth compactly into a glass bottle, placed his captured colony upon the surface of this earth, and left them to establish their new home in their own way. It was not long before the workers were busily engaged in the business of excavating; galleries were speedily formed in the earth, and the mined-out materials deposited upon the surface. But in this active labour the comfort of the poor honey-bearers was utterly ignored. They lay helplessly where they had been dropped, and were treated by the other ants as if they had been so many lifeless impediments to their work. For, instead of making a detour around them, the workers went straight forward, clambering over any of these helpless magazines of sweets that lay in their path, and even dropping the pellets of earth which they brought out from the excavations upon and around them, until some of the honey-bearers were almost buried by their own heedless friends.

There seemed here, indeed, a double lack—a lack both of

sympathy and of intelligence. In the new circumstances under which these ants were placed, their strongest instinct —that of excavation—at once displayed itself; but they seemed quite incapable of handling the question of the proper disposal of their food-magazines, under such unusual conditions. Fortunately for the honey-bearers they were not quite helpless, despite the great weight which they bore. They were able to drag themselves slowly forward, and in time they seem to have all managed to reach the underground habitation without aid from their friends. At least such was Dr. McCook's belief, although he did not observe the complete process. There was no evidence of any assistance from the workers.

Observations made in the natural nest of these ants gave different results. When they were dug into for the purpose of examination, and ants of every age and caste exposed to the light of day, the workers made the most vigorous efforts to carry all their helpless charge into the unbroken galleries of the underground city. The eggs, the young, and the honey-bearers were alike carried to this place of safety, with the most devoted energy. Whether the honey-ants were replaced in their favourite position on the ceiling of their chambers is not so certain. In our former article the workers were spoken of as so replacing them. But this statement was not derived from actual observation, but from the fact of their being often found in this position on further excavation.

There is some reason, however, to believe that they may have regained this position by their own efforts, to judge from facts observed in the artificial formicary. As already mentioned, the honey-bearers are not quite helpless: they have the full use of their legs, though their movements are necessarily made at a disadvantage, from the angle into which the head and thorax are thrown by the swollen condition of the abdomen; yet they have been observed to move by their own efforts, and it is not impossible that they themselves regain their favourite position on the ceiling of the nest. The reason of their preferring this position may be from the uncomfortable attitude which they are forced to assume on the floor of the nest.

It may seem that an intense muscular effort would be required to sustain their great weight in this position. That ants, and insects generally, are excessively muscular, as compared with the larger animals, is well known. And the honey-bearers are more muscular than ants generally, their legs being simply bundles of powerful muscles. But it is

rather difficult to conceive how muscular effort can be brought to bear to overcome the action of gravity in this position, unless by some clasping of the terminal hooks of the feet around the excrescences of the rough ceiling. It seems more probable that support is gained by the action of the pulvillus, or sucking-disk,—that cushion-like organ which ants possess in common with so many other insects, and which enables this class of animals to walk on smooth surfaces in a vertical position. If the honey-bearer thus brings suction to bear to aid in its support, it simply avails itself of the natural force of atmospheric pressure to overcome the force of gravity, and has no occasion for muscular exertion as an aid in sustaining it.

The main argument against any aid from the working ants in replacing fallen honey-bearers comes from observations of their behaviour in the artificial formicary. From various causes these ants occasionally fell to the floor of their chambers, often alighting in the most uncomfortable positions. In some instances they lay on the base of the rounded abdomen, with the head and thorax upward, looking not unlike the old-fashioned flat-bottomed Dutch dolls; in other cases they lay head downward, quite buried under their load of sweets. Yet, uncomfortable as these positions must have been, the working ants made no efforts to replace them in a more desirable position, much less to carry them back to their elevated dormitory. They would attend to their wants so far as the need of cleansing them was concerned, but no further.

To discover if the honey-bearers were satisfied in these unnatural postures, Dr. McCook tried the expedient of introducing a straw or broom splint to such as were within his reach. In every instance he found them to vigorously grasp this substance, and to cling to it until they were drawn into a more natural posture.

This evidence of lack of sympathy with friends in trouble was strengthened by another observation. On one occasion a large piece of compact earth fell upon one of the honey ants, burying and compressing its abdomen, and leaving only the anterior portions of the insect visible; yet the other ants made no effort to relieve it from this difficulty, which they could readily have done, but moved about it with the most supreme indifference to its unfortunate condition.

An observation of some importance in respect to the question of ant intelligence is that regarding the demeanour of the ants towards dead honey-bearers. In this case it is

their habit to separate the head and thorax from the honey-bag, burying the former in the fixed cemetery which these ants usually establish in the earth outside their nests. But though the honey-bag remains, full of its sweet contents, the ants—either from respect for the dead or from lack of mental power to devise a new means of getting at its honeyed freight—seem to make no effort to penetrate its transparent wall. This is singular, in view of the avidity with which they will lick up the smallest portion of sweet food offered them in any uncovered condition.

We may supplement our remarks on these evidences of lack of personal sympathy and of benevolence in the honey-bearing ants with some description of their anatomy. In our former article it was said that the whole abdomen appeared to be occupied by the honey, its organs seeming to be obliterated, so that only a thin transparent skin remained. But anatomical observation shows that this external appearance does not give the true facts of the case. All the abdominal organs remain, but so strangely distorted and compressed as to be almost imperceptible. The fact is that any of these ants may, if necessary, be converted into a honey-bearer, and that the worker, when on her way home with her abdomen distended with the fruits of her nocturnal labour, has made a step towards the condition of the fully-developed honey-bearer.

It need scarcely be repeated that the intestinal tract of the abdomen of the ant is possessed of three special expansions, named respectively the crop, the gizzard, and the stomach, from their relations in function to the similarly-named organs in birds. Of these the crop, into which the œsophagus immediately opens, is the recipient of the honey. As its stores increase, by continual additions, it expands more and more, pressing outward the extensible walls of the abdomen, and compressing the remaining portions of the intestine into a smaller and smaller space.

In a fully-laden honey-bearer the crop has become so expanded that it fills nearly the whole interior of the greatly dilated abdomen; the dorsal vessel, or heart, being compressed and flattened against its upper wall; while the gizzard, stomach, and intestine are similarly compressed against the posterior wall. The compression of these organs is so great as seemingly to preclude their functional action, the stomach appearing to be quite incapacitated for its normal office of digestion. Yet the continued vitality of the ant is sufficient evidence that alimentation must still exist; and as it is not at all probable that the crop could assume

the function of a digesting organ without injury to its stores, it seems as if some of the liquid food must make its way into the stomach and intestine, despite their extreme compression, and be there prepared for aliment.

It is, in fact, a puzzling question. Dr. McCook is inclined to think stomach digestion, in some instances, impossible. But the continued vitality of the ant seems to render it necessary, despite its apparent impossibility.

III. THE "LAWS OF EMPHASIS AND SYMMETRY."

By J. W. SLATER.

THE presence and the distribution of colour in the organic world have not passed unnoticed in the "Journal of Science." Sexual selection, the need of concealment, the influence of light, of temperature and diet, and even certain "waves of beauty," have all been put forward as affording partial or complete solutions of the questions involved. No one, however, will contend that the explanations given are fully satisfactory, or indeed cover more than a corner of the subject. The general rule with those naturalists—and unfortunately also un-naturalists—who have attempted to show why an animal displays some particular colours in some particular design is to overlook all phases of the subject save the one which has first attracted their attention. But are the chemico-physical, the vital, and the utilitarian theories of animal colouration necessarily contradictory and mutually destructive? I think not. Suppose it is shown that an animal of some given colour harmonises better with its surroundings than if its hues were modified; it may then be argued that, on the principle of the Survival of the Fittest, individuals of the species in question will have been able to escape the notice of their enemies, and to leave posterity the more successfully, the more decidedly they possessed such colour. But it is surely not contradictory to this explanation if we point out some constituent in the food of the species from which

the colour may have been derived. On the contrary, the two principles seem to support each other. To take an especial instance:—It has been explained that larvæ which feed upon the leaves and stems of plants in open daylight assume a green colour, like the objects by which they are surrounded; whilst those which prey upon roots, bark, and wood, and especially such as pass their existence in the dark,—whether under ground or in the interior of fruits, seeds, or trunks of trees,—are of a pale grey or livid colour. All these facts are doubtless intelligible on the hypothesis of "protective colouration." But they are also by no means antagonistic to a chemical explanation. The present writer has pointed out, on a former occasion,* that larvæ feeding upon leaves may readily be coloured green by retaining in their tissues, in an undecomposed state, the chlorophyll contained in their diet. On the other hand, larvæ which feed upon substances devoid of chlorophyll may be considered much less likely to display a green colouration. Thus the caterpillars of *Cossus ligniperda* and of *Zeuzera æsculi* are not green; but they have not been consuming a green pigment. The same rule holds good with the larvæ of the Elateridæ, the Buprestidæ, Lamellicornes, Longicornes, &c. It may surely be submitted that before a mimetic or otherwise protective colouration can be developed by the agency of Natural Selection the material for the production of such colour must be present. It is, of course, admitted that many caterpillars consuming chlorophyll are not green; but in these cases their colours are such as may be formed by the decomposition or modification of chlorophyll,—colours such as we see actually produced in the leaf when fading. The difficulty remaining is to know why in some species the green pigment remains unchanged till the insect reaches maturity, and why in others it is immediately decomposed, or at least disappears after some time. Why is the green colour in *Chærocampa elpenor* sometimes absent in the larva, and why does it appear in the perfect insect? We may say that the chlorophyll is altered by oxidation, and restored to its original condition by a process of reduction. But why do these changes take place in some species and not in others whose vital conditions are, as far as we can judge, essentially identical? At the same time, when we seek to account for these peculiarities of colour and design on the principles of mimetism and protection, the same questions still lurk in the back-ground: how are the colours requisite

* Quarterly Journal of Science, vol. viii. (1878), p. 48.

to make a species inconspicuous elaborated, and how are they despatched to the parts where we find them?

Certain interesting and novel ideas on these subjects have been recently brought forward by Mr. A. Tylor, in a Paper read before the Anthropological Society.* He considers that the forms and decorations of organised beings seem to be regulated by laws which he calls those of Emphasis and of Symmetry.

Symmetry, of course, calls for no explanation, as it is generally known that the two lateral halves of vertebrate and articulate animals are substantially alike, both in form and colouration, exceptions in the latter respect being scarcely more common than in the former, save among certain domestic mammals, such as horses, cows, dogs, and cats, which, when not concolorous, frequently show a different design on the left and the right side of the body.

Emphasis, Mr. Tylor defines as the marking out by form or decoration of the important parts or organs. He considers that the emphasised functional decorations group themselves into two classes, and that these classes coincide in their occurrence with the two great divisions of the Vertebrata and the Invertebrata. In the former class the emphasised ornamentation is axial, being the outward expression of the vertebral column with its appendages. In the Invertebrata the decoration tends to follow the outline of the animal, and so developes borders.

These generalisations deserve a careful examination. In the Invertebrata, or at least in the Articulata, borders marking the outline of the body, or of some particular part, or running parallel with such outline, are of very frequent occurrence. The margins of the wings of butterflies are very often coloured differently from the disk of the wing, and there are often repetitions of the outline in the form of bands and lines of spots as we proceed inwards. Such patterns occur to a great extent in genera and families by no means closely connected, and have often excited the attention and the comments of naturalists.

In considering these designs, which seem, so to speak, based upon the outline of the wings, the idea at once suggests itself that they may be—in part at least—explained by the well-known phenomena of capillarity and of the varying

* "On a New Method of expressing the Law of Specific Changes and Typical Differences of Species and Genera in the Organic World, and especially the Cause of the Particular Form of Man."

diffusive power of different colouring-matters. Everyone must have observed that if a coloured liquid, not too intense in its shade,—*e.g.*, wine or tea,—is allowed to fall upon some white fibrous material, the spot produced will be darkest at the edges, whilst in the centre the linen or paper will scarcely appear stained. If, again, several colours differing in diffusibility are dissolved in the same liquid, they may be to a certain extent separated from each other on the same principle. Thus in the earlier days of the manufacture of the aniline dyes, samples were often met with which—from inattention or from imperfect purification—consisted of two or more colouring-matters mixed together. To detect such mixtures it was usual to place a drop of the solution on a sheet of white blotting-paper, when the different colours appeared as concentric rings. If we suppose the tinctorial matters present in the fluids of the butterfly towards the close of its pupa-life being liberated in the porous tissues of the wings, we can form some remote conception of the manner in which these patterns are produced.

It will perhaps, however, be asked by some naturalists whether the parts where these borderings chiefly occur—*i.e.*, wings and elytra—can fairly be pronounced "important parts" in the same sense as is the central axis in vertebrate animals? Mr. Wallace* points out as a remarkable fact that black spots, ocelli, and bright patches of colour are generally on the tips, margins, or disks of the wings, at a distance from the vital organs, and considers that this position of the more conspicuous parts may be a protection to the insects.

In vertebrate animals Mr. Tylor considers that emphasised ornamentation has what he calls an axial character, "being the outward expression of the central axis or vertebral column with its appendages." It is perfectly correct that in a vast number of vertebrates the head is prominently decorated, and in many mammals and reptiles the back is adorned with stripes, or chains of spots, from which other stripes branch off at right angles, or nearly so, to the main axis of the body. In birds I believe a dorsal stripe, if it occurs at all, is very rare. This design, in which the contrasting colours are often very striking, is referred to in the "Journal of Science,"† and is there traced much more widely among Articulata than among vertebrate animals.

* "Colours of Animals and Plants," in Macmillan's Magazine, No. 215, p. 402.

† February, 1879, p. 196, and July, 1879, p. 496.

The central line, indeed, is often wanting, but the lateral bands take their origin where such a line would run, or intersecting it from one side to the other. Such lateral bands, with or without a distinctly marked axial line, occur on the abdomen, are met with in many Homoptera, and in certain Lepidoptera, such as Sphingidæ, Chelonidæ, &c. Among Coleoptera, where the transverse stripes occur in groups too numerous to mention here, they run across both elytra. It would seem, therefore, that among invertebrate animals both these kinds of decoration prevail, whilst among vertebrates we find the axial designs alone.

Mr. Tylor's views, however, call for further investigation.

IV. INSTINCT AND MIND.*

By S. Billing.

At page 339, in the May issue, appear some observations by R. N. M., on the article "Instinct and Mind" in the April issue (p. 288).

My object in framing the paper was to set forth distinctively the views I hold of the differences, so to speak, of the mentality apparent in men and animals. I do not object to a fair discussion of the propositions which therein appear, as my sole object was to elicit the truth, and in a measure to answer the unflinching materialism with which the *savans* of the day envelope the subject. On the assumption that Descartes had said so, animals are pronounced to be automata. This authorisation of Descartes for the automatic theory the late George Henry Lewes wholly denied (*vide* "Physical Basis of Mind"). The halt is not made with animals; men also are pronounced to be automata. The logical corollary certainly would be that if animals are automata, men are also. All the facts, physical and psychical, set forth on this subject lead directly to a contrary inference. The objection I have to R. N. M.'s note, to say the least, is that his interpretation of my views is wholly

* Sequel to article at page 228.

erroneous, and that the only answer to the phantom he has set up should be one of negation.

When a subject is treated upon general principles, particularisations, unless for the purposes of illustration, are generally avoided; and had I said, when speaking in illustration of the particular instincts of animals, as dogs, &c., that of course I do not mean that each individual has the exact sagacity of every other individual of the species,—had I adopted this course I should have felt that I was needlessly ignoring the common intelligence of your readers: but as there appears to be one among them who cannot, or will not, understand plain and terse reasoning, I will endeavour to particularise.

When I speak of the aptitude of varieties or species to work in a given direction, which I term tribal instinct, I neither say, infer, or mean to say, that there are not different exemplifications of the particular potence or sagacity. If it were not so, what would be the use to animals of the discriminative capacity (instinctive mentality) I ascribe to them? Dogs and other creatures possess character in expression and in act. I do not say, or mean to say, that all have the same aptness, *i.e.*, that the characteristic which is applicable to the variety has received the same development in each individual of the variety or species. Dogs and other creatures vary as much as men do, the difference to be found with them being one of degree; *e.g.*, all men possess the power of abstract reasoning, but all men do not exemplify it in the same degree. The varieties of birds build their nest in the same pattern, but all are not equally neat in the display of the constructive faculty.

In the article in question, when speaking of tribal instincts, I generalised, and it seemed to me the cultural power which makes the difference between individuals of the same class would have been understood; therefore, in the face of the unfounded assumptions of R. N. M., one of two things must be assumed,—either that I am wanting in common observation, or that he is incapable of comprehending the argument he attacks. As to dogs, every person, not sportsmen only, knows that there is a broad distinction between the sagacity of one sporting dog and another; but this does not imply a variation in the characteristics of the particular species. One dog, according to its adaptability for its particular purpose, may be worth a large sum of money, whilst another dog with the same characteristics, but without the same development, may for the particular purpose be worthless. It is the same with shepherd's dogs

(collies). I neither asserted nor inferred that there was no distinction between them in capacity; nor do I say or infer "that every shepherd's dog is equal in intelligence to every other shepherd's dog;" but I do say that one shepherd's dog displays the same instincts as every other shepherd's dog. All this is very puerile, and I am almost ashamed in being compelled to write it.

The broad distinction I draw is that instinctive mentality (the animal attribute) and abstract intellectuality (the attribute of man) are not the same, *not even in origin*. The one, being derived from the senses, is shared in common with the animal and animal man; the other, the intellectuality which deals in abstractions, has no place in the sensuous expressions, and is possessed by man alone. Animal instincts are developed in particular directions, and the characteristics they exemplify run through the whole race, tribe, or species. If it were not for this particular tribal development there would be no distinction as class, variety, race, or species, and all animation would be one indistinguishable mass or confusion. I do not suppose that the peculiar characteristic running through the tribe has its expression or development in an equal degree in each individual composing it, as I do not suppose that all men have the critical acumen in an equal degree; but I do suppose that all men have a critical acumen.

As R. N. M. appears wholly to have mistaken the drift of the argument,—for in no way do I infer that the instinctive *mentality* is equal in each member of the species,—perhaps he will trouble himself by reading the article again, when probably he may take a new view of the subject, and assure himself that the author does not ascribe a mental equality to the members of each species.

V. TUBERCULOSIS TRANSMISSIBLE THROUGH THE MEAT AND MILK OF THE ANIMALS AFFECTED WITH IT, WHEN CONSUMED BY YOUNG CHILDREN.

THE following Memoir, read before the Farmers' Club of the American Institute, by the President, A. S. Heath, M.D., has been courteously forwarded to us at the author's request :—

In 1865 Villemin proved, by repeated experiments, that it was possible to produce consumption in previously healthy animals. He found that finely-divided tuberculous matter, when introduced under the skin of rabbits and guinea-pigs, produced tubercles in three weeks in their lungs; thus proving from these experiments that *tuberculosis* should be classed as a specific infective disease, capable of being conveyed by inoculation, like small-pox or syphilis. Numerous pathologists have verified Villemin's experiment. It was also found, by Dr. Wilson Fox and Dr. Sanderson, that pneumonic matter, pus, putrid matter, &c., would produce disease in healthy animals, and transmit it through their meat and milk, to dogs, cats, hogs, and through milk to young children and animals to whom it had been fed.

Cows living under bad hygienic conditions, as in man, under similar conditions predispose to tuberculosis in themselves, and render their milk poisonous to children. In New York city most of the cows are diseased from this cause, and by being fed on unsound food.

In a future *paper* I shall pay my special respects to city cows and *cow stables*, and show, I trust, that the milk from diseased cows poisons thousands of city children, who are supposed to die from *cholera infantum*, when, in fact, they die from tubercles of the intestines, resulting in wasting diarrhœa. Consumption is infinitely more common in city-kept cows than it is believed to be, even by physicians. I recently called Prof. Chandler's attention to the unusual number of cows crowded into city stables; and from his taking copies of notes sent to me by Dr. James D. Hopkins, I feel assured that so efficient a sanitarian as he is will have these nuisances abated, and promptly too.

Tuberculosis prevails extensively among domestic animals over the entire globe, and especially in populous and crowded localities. In Mexico 34 per cent of slaughtered animals supply tuberculous meat, and it is probable that the milk cows are affected to the extent of 50 per cent in the large towns.

Van Hertsen, of Belgium, found tubercles in all the tissues of an apparently healthy bull seven years old. From these facts it is apparent that there is great danger in eating uncooked beef, for fear of contracting consumption. The sources from which consumption are derived is now known to be infinitely more numerous than former pathologists supposed.

It is more dangerous to eat the milk of tuberculous animals than to eat the meat; for the milk is seldom cooked, while the meat is almost always cooked. Cooking is a most valuable sanitary measure. Cows confined in dark, damp, unventilated city stables, become tuberculous eventually to the extent of 75 per cent. Fleming says:—"For it must be borne in mind that there are few animals which have been kept for any length of time in cow-sheds, and fed and milked in the usual manner, which are not more or less phthisical: more particularly is this the case if the dwellings are bad."

The milk of tuberculous cows is of a poor quality, besides being liable to produce the disease.

Klebs has produced tubercles in rabbits, guinea-pigs, and dogs, by giving them the milk of diseased cows.

This milk given to young children produces catarrh of the intestines before the tubercles are deposited in the lungs. It is not often that the intestines of young children who die from what is supposed to have been *cholera infantum* are examined after death; but doubtless tubercle of the intestines would be frequently found.

Garlach and others have demonstrated that the milk of tuberculous cattle will produce phthisis in creatures fed with it.

Fleming says:—"It is certain that *tuberculosis* is a somewhat common and a very destructive disease, among dairy cattle especially, and more especially those of towns." And *consumption* is one of the most fatal diseases of large cities, and doubtless from this cause. Marasmus is undoubtedly largely attributable to diseased milk, and many thousands of children perish from *tuberculosis*. The excessively hot weather of parts of July and August is productive of an irritable condition of the stomach and bowels of young and teething children, which condition

acid, impure, or tuberculous milk greatly aggravates, and renders poisoning with diseased milk from unhealthy cows more common than it is popularly known.

Neimeyer says that the predisposition to consumption is strongest in persons of feeble and delicate constitution, and especially that children poorly nourished are most subject to the disease. The children fed on the milk of tuberculous cows must, of necessity, suffer in a twofold sense—from bad food, and poisonous food also. From a seventh to a fifth of all deaths are caused by consumption, and nearly half of the *post mortems* show the traces of nutritive disorders from which pulmonary consumption proceeds, and "consumption of the bowels" is the more frequent form of the disease in children, as a result of bad food and diseased milk.

It has always been my aim to be suggestive in my papers rather than exhaustive, and, as lawyers say, "I here rest my case."

VI. NATURAL SCIENCE AND MORALITY.

By S. Tolver Preston.

> "I say that Natural Knowledge, in desiring to ascertain the laws of comfort, has been driven to discover those of conduct, and to lay the foundations of a new morality."—Huxley, *on the Advisableness of Improving Natural Knowledge.*

THE view that happiness must be the standard of morality has recurred again and again, as if by inevitable logical sequence, to the leaders of thought in all time; and this doctrine is so well in accordance with the most advanced modern ideas that it will not be our task to inculcate this maxim here, but rather to attempt to reconcile some of the difficulties which appear to beset its universal adoption as a standard of morality.

The grand difficulty that has stood in the way of this has been the opinion that the pursuit by the individual of his own happiness, or a regard to his own interests, clashes with the interests of others, tends to make the individual prey upon the rest of society, and is subversive of all harmony

and concord; in fact that self-interest and selfishness are synonymous, and that by such a moral standard that desirable consummation, the greatest happiness of the greatest number, would be rendered an impossibility. The late John Stuart Mill, in his celebrated work "Utilitarianism," while fully recognising the worth of happiness as a standard of morality, was nevertheless probably led by the above-mentioned difficulty to advocate the maxim that each one was to make his own happiness *subservient* to that of the greatest number,—a dogma that must fail in practice, owing to the absence of logical incentive to carrying it out. Our task will be to show that, so far from the greatest happiness of the greatest number being inconsistent with each individual consulting his own happiness, this desirable consummation can only be attained by that means.

One hundred and sixty-six years have elapsed since Bernard de Mandeville argued that self-interest being the guide of action, "those creatures would flourish most which are least possessed of understanding; for the more they know, the more would their appetites to be satisfied *at each other's expense* be increased, and therefore the more would they war with and exterminate each other." Whence man, by reason of his understanding, would be least fitted to agree long together in multitudes.*

The Grand Jury of Middlesex of that day were seized with a panic: they seem to have feared that De Mandeville's theory, that society rested upon a fiction, was true, and therefore to have burned the book in which that fiction was exposed. The panic has not yet subsided. Many worthy people dread the theory of the Survival of the Fittest, because, while they recognise that the fittest are those who can best provide for themselves, they are still chained to the old error which supposed selfishness to be the ideal practice of self-interest.

Before the dawn of Political Economy there was some plausibility in the theory that the wealth of the individual could only be increased at the expense of his neighbour, and that consequently true happiness was only to be found in a

* "An Enquiry into the Origin of Moral Virtue," appended to the republication (1714) of "The Grumbling Hive." It is interesting to notice that although self-interest is recognised here as the incentive to conduct, there is a failure to reconcile it with order and stability in society, or only *half* the truth is recognised. This was the same with Hobbes (as related in the "Leviathan"), and with many others. For an admirable and lucid sketch of some of the more important systems of morality, the reader may be referred to LANGE'S notable historical work "Geschichte des Materialismus" (of which we believe an English translation is now published).

"small and peaceable society, in which men, neither envied nor esteemed by their neighbours, should be contented to live upon the natural products of the spot they inhabit."* But now that we have to face the fact that a savage who lives solely on the produce of the chase is tolerably reckless of the life which requires some 78 square miles for its sustenance, while a Belgian clings to that which is supported on 2 acres,† we are driven to the inference that there must be some flaw in Bernard de Mandeville's conclusion. For the purpose of his argument De Mandeville, in analogy with Hobbs and others, took the wealth to be extracted from a given area as a constant quantity, left out of account man's labour, and estimated the happiness of the individual in any country by dividing the uncultivated (or natural) products of the country by the number of inhabitants. Political economists have reversed all this; they recognise labour as a source of wealth whose value varies with the intelligence and sociability of the labourer; so that the wealth of *each* individual may be greatly increased by co-operation of numbers.

If De Mandeville had been right in assuming the total wealth to be constant and independent of man, he would, of course, have been correct in the deduction that through self-interest each individual would increase his own wealth at the expense of his neighbour; but when the facts are known that in the most wealthy countries the proportion derived from natural or uncultivated products is almost insignificant compared with that which can only be obtained by the co-operation of numbers of individuals, it is certainly remarkable that some Utilitarians of the nineteenth century should fall into the error that the pursuit by man of his own self-interest would be synonymous with selfishness, or would tend to make him isolate himself from his neighbours, and prey upon them; whereas we may see, from the above considerations, that precisely the reverse of this may be true, or that sociability and co-operation may be in reality the highest forms of self-interest.

Nor can that purely passive selfishness which stops short of actual dishonesty (the ordinary selfishness of private life) be carried out in an intelligent society without great loss to the individuals who practise it. For it is an every-day occurrence for A, by relinquishing a small pleasure, to be able to render a large service to B; and when under such circumstances A does so sacrifice his own immediate smaller

* Bernard de Mandeville, Fable of the Bees.
† Lubbock, Prehistoric Times, 4th ed., p. 607.

happiness, his action should be determined not by the dogma that, "between his own happiness and that of others, Utilitarianism requires him to be as strictly impartial as a disinterested spectator,"* but because he clearly perceives that if all agree to act similarly, all, including therefore himself, will be benefited. To-day A relinquishes a small pleasure, and B gains a great one: to-morrow B may do the same for C, C for D, and so on, until ultimately *Z* may sacrifice his own immediate smaller happiness for the greater happiness of A. Seeing, then, that by the practice of unselfishness each individual in our mutual-benefit society has succeeded in exchanging a smaller pleasure for a larger one, it seems but natural to describe unselfishness as self-interest, and it appears to be only by a most unfortunate oversight that the late John Stuart Mill persisted in repudiating the idea that it was desirable for individuals to act each for his own interest.†

But if selfishness is the opposite of self-interest, by the practice of which civilised man would quickly reduce himself to the condition of brute beasts, it becomes easy for the naturalist to conclude that man may have evolved himself from some lower form simply by virtue of improvement in power to detect his own self-interest. Dimly perceiving the advantages of association, mankind has in this view gradually drifted by the rude method of trial and error into codes of written and unwritten laws, which, less or more efficiently, make selfishness immediately disadvantageous to the individual who practises it, so that the simple guide of action for each and all may be self-interest. Thus, to take a simple case for mere sake of illustration: if an intelligent man, influenced solely by the desire to obtain certain goods

* Utilitarianism, 1863, pp. 24, 25.

† "I must again repeat what assailants of Utilitarianism seldom have the justice to acknowledge, that the happiness which forms the Utilitarian standard of what is right is not the agent's own happiness, *but* that of all concerned."—MILL, *Utilitarianism*, 1863, p. 24. The important word "but" is italicised by ourselves: it implies the incompatibility of two interests which, as we contend, actually coincide. Mill also remarks that there is "happiness in absolutely sacrificing one's own happiness to the happiness of the greatest number."—(Pp. 24, 25.) This apparent contradiction, or seemingly irreconcilable statement, can be due to nothing else than the failure to realise that the happiness or interest of the individual need not be incompatible with that of the greatest number; but that it may be to the interest of the individual to forego certain benefits for the sake of gaining the esteem and friendship of his fellows, the reward of whose esteem would more than compensate the privation undergone, so that no absolute "sacrifice" of happiness would occur. Indeed, no doubt one of the principal rewards of the labours of unselfish people is to be found in the inestimable prize of the real and cordial friendship of their neighbours and companions.

at the least possible expenditure of labour, could earn them in ten days, acquire them in an underhand manner in one, the risk of detection in the latter case being, say, one to ten —then a penalty (fixed by society) of something more than 100 days' labour, in the event of detection, would be sufficient to make him see that it was to his interest to adopt that method of obtaining the said goods which was concurrent with the interests of his neighbours. Or again, if one man, observing that his neighbour never dreamed of going a step out of his way to help anyone else, himself resolutely determined not to move so much as a little finger to his neighbour's assistance, it would not be long before passive selfishness died out. For not to retaliate would be to offer a premium on selfishness, just as not to punish a theft would be to offer a premium on thieving, or to encourage it. Selfishness is analogous to thieving (in kind at least), since by it an individual obtains an unfair advantage at the expense of his neighbour. The course taken by society must obviously be to act so towards selfish persons that selfishness (like thieving) is rendered unprofitable, or against the interests of the individual who practises it. This is tacitly done; but unfortunately, as regards *doctrine*, the contrary maxim is commonly preached, though in practical life it never can be and never is acted upon, as indeed it would be highly undesirable if it were. The apparently amiable doctrine that one should return good for evil, love one's enemies, &c. [like some other maxims that may recommend themselves on a superficial view], shows itself on analysis to be highly dangerous, constituting the strongest possible incentive to selfishness, and consequently the general practice of which would ruin society. From the very fact, however, that the ideal aimed at in this kind of doctrine is unattainable [on account of its inherent defects], it unfortunately comes on that account to be looked upon as something nobler and above this world, and forms a never-ending resource for sermonising and for characterising mankind as "miserable sinners." It may be safely concluded that the larger proportion of the asserted wickedness of this world is of clerical imagination. Without inquiring too closely into (perhaps unconscious) motives, it is none the less obvious that the more degrading the picture drawn of humanity, or the blacker the colours in which this world is painted, the brighter must the painters inevitably appear by contrast, and the stronger must seem the motive for their *raison d'etre*. This is unavoidable, and it must at least be admitted that the colours selected to paint humanity are of sufficiently sable hue.

If, instead of preaching the "wickedness" attendant on breaches of the law, society were to take care to inculcate on its members the advantage which accrues to each from the general practice of honesty, and to point out the efficacy of the arrangements it has made accordingly to prevent an occasional selfish man, residing among unselfish neighbours, from advancing himself at their expense,—in short, if it were taught that the question of honesty and dishonesty was one of profit and loss (or that knaves in the long run *are* fools), —then probably less machinery would suffice for the repression of crime. Unfortunately, however, popular religious doctrine seems to dissociate rather than to identify the path of virtue with that of self-interest; as, for example, we have the saying about the "thorny and difficult path of Virtue," and the "broad and easy path of Vice,"—which, of course, is tantamount to setting a premium on vice. And yet what could be more contrary to the truth than the spirit of this kind of doctrine? Also there can be no doubt that the holding out of rewards and punishments in a future world is a strong incentive to crime; for it is justly argued by the would-be delinquent that if virtue require a future reward, it cannot therefore be remunerative in this life, or the practice of virtue cannot be consistent with self-interest. Since, therefore, the belief in a future world is necessarily very shadowy, the criminal naturally infers that it is desirable to tread the "broad and easy" path of Vice. Moreover, when it is commonly taught that such and such a course is "wicked," one may be inevitably led to conclude that in the absence of any more tangible reason than this against it the course must be advantageous.*

* There can be little doubt that one of the main causes for war may be reasonably traced to the continual preaching that it is "wicked," a vague phrase whereby a sort of attraction is attached to it, and the fact pushed out of sight that self-interest is the principle to appeal to here (or that it is futile to attempt to dissociate right from self-interest). For since the principle of co-operation and association is the very essence of the morality of self-interest, it would be seen that, from the fact that war strikes directly at the root of this principle, it violates the fundamental groundwork of the self-interest morality. Indeed men have already learnt this fact in their individual relations, and its influence has always been spreading wider and wider. We know that formerly, in feudal times, people inhabiting small tracts of country, or even families and near neighbours, used to arm themselves and be in continual war with each other; and even the croakers [or "parrots of society," as the late Charles Dickens called them], who think the world goes backwards, and say that disarmament is impossible, laugh at the folly of the feudal times. It can only be a question of lapse of time for an appreciation of this folly to extend to larger tracts of country (or nations). Certainly the self-interest morality will have a great field here. The total violation of interests indicated by the self-inflicted punishment of the crushing armaments under which nations groan at present, affords a pitiable instance of the absence of self-help in reasoning beings (or

A little power of penetration should suffice to discover that a civilised man (or a man of high intellect) is capable of more happiness than a savage, and that in a civilised society an individual is more or less directly dependent upon the goodwill of his neighbours for almost all his pleasure in life; whence it follows that desire for happiness on the Earth alone would itself induce all intelligent people so to conduct their lives as to secure the friendship of their fellows. For this purpose the strictest honesty and sincerity, practised as an undeviating *principle*, is obviously indispensable. For where would be friendship without sincerity? When one considers that a man must have a *character* for honesty and sincerity in order to secure the pleasure of the real esteem and goodwill of his fellows, and that a *single* act of dishonesty or deceit may destroy his entire character (or reputation), one may see how utterly insignificant the temporary gain due to such an act would be compared with the prospective loss attendant thereon, and therefore on how firm and impregnable a basis stands the morality of self-interest.*

It is only to the absence of adequate appreciation of this fact, and the sort of fear that society rests upon a fiction, that some of those monstrous and terrifying doctrines unfortunately identified with religion can be attributed. To select a single example as a representative case: could any greater incongruity be imagined than the coupling of a God of Love with *eternal* punishment? *i.e.*, a punishment which (measured by its duration) is *infinitely* greater in amount than that which the most implacable hatred could devise or

---

the absence of power to come to an agreement for their own advantage). The time may not be far distant when such a state of things will come to be looked back upon with something like contempt.

* It is a noteworthy fact that if the lives of those men who have accumulated such *exceptional* fortunes as to call for biographies be examined, it will be found that *exceptional* integrity and honesty were the main characteristics of all their transactions, which was the secret of the unbounded confidence inspired in their business relations. These men possessed sufficient power of penetration to see that that superficial sharpness which imagines an advantage in a little deceit or duplicity is in reality no more than stupidity. The parable of the unjust steward, who attempted to deceive by inducing his lord's debtors to falsify their accounts, contains exactly that exterior of superficial shrewdness which may be well adapted to mislead the unthinking; but it will scarcely injure a man of intellect. He will see plainly enough that, so far from unjust stewards being "*wiser in their generation*," they are in reality fools (irrespective of any time or epoch). Nevertheless, can we wonder that dishonesty and underhand dealings are still so rife, when doctrine of this kind is actually included in the code of moral instruction.

the most outrageous injustice invent.* Dogmas of this nature are simply illustrations of the lengths to which doctrines may go without universal repudiation, when society has an instinctive dread that to disclaim them openly would affect injuriously its own stability. It is the old instance of the baneful influence of the false idea that good can ever come out of error. In short, it is only necessary for anyone to reflect impartially on the subject (especially from the points of view indicated) in order that the evil which has resulted from such doctrines may make itself plainly apparent; and their retention after the true groundwork of morality is recognised could not be palliated by even the semblance of an excuse. Indeed such dogmas constitute an evident insult to the justice and goodness of the Deity: that they are precisely of that character which is calculated to allow Clericalism to predominate over the rest of society is unquestionable, whether that motive had any part in their original invention or not.†

At the same time, is it not a melancholy consideration that doctrines of the above character (though happily excluded from our Board Schools) are still taught to young children, at the very dawning of their mental faculties, before they are sufficiently matured to distinguish truth from error, and without experience to know representative opinions (especially those of the unbiassed and intellectual few) on these subjects. Thus the child imagines himself isolated in his opposition to these doctrines, and years may be miserably spent and intellectual energy wasted in fruitless

* According to this dogma of infinitely lasting punishment, the punishment for vice in this life would be *infinitely* inadequate, which is practically tantamount to teaching that the pursuit of vice must be infinitely profitable in this life.

† Putting the case as an *à priori* problem (as is sometimes usefully done in physics),—then, in order to predominate over the rest of society, the condition fundamentally required is to appeal in the strongest possible way to the interests of mankind, by inventing some startling and terrifying danger, together with some remedy or means for escape equally startling and exceptional (if possible); when the rest of society will naturally run after those offering the remedy as their rescuers and benefactors. [It almost unavoidably reminds one of the story of the bees who offered their comrades Heaven, and took the honey.] If, in the attempt to strain the magnitude of the danger to an extreme pitch (illustrated by making the punishment *eternal*), the limits of justice be passed, this is a matter of secondary consequence; since the very incongruity of the doctrine, especially if coupled with an affectation of mystery (which applies equally to the scheme of escape proposed), may tend to make it fascinate all the more, from its seeming originality. It is a well-known fact that it is the policy of men who exercise an ascendancy over others never to be sparing on the side of boldness, since the very audacity of the incongruities indulged in may tend to cause additional cringing rather than revolt. The more intelligent portion of mankind may not be disposed to examine the error too closely, from a sort of undefined idea that it may conduce to the stability of society.

efforts to reconcile the impossible, in the vain attempt to put in practice unnatural and ridiculous moral maxims,* or in the struggle with beliefs that disintegrate the mind. Of this one of the authors of this essay† can speak from personal experience (as no doubt many others could); and all this is assumed to be necessary to benefit society in general, as if society rested upon an unstable basis that required fictions to support it. Fortunately the majority escape this evil of young days, simply because they do not inquire into or realise what is taught them; and it would be all the same, in their case, which of the thousand and one creeds of the world were inculcated.‡ Youthful minds of an exceptionally penetrating and inquiring character run the greatest risk of becoming hopelessly entangled here, or it is reserved for the most inquiring and thoughtful, and therefore probably those who would have exceptional capacities for becoming useful members of society, to bear the brunt of this, in order to sustain a system for the fictitious benefit of the many.

That there is no limit to the depths of absurdity and superstition to which even men of education will descend (and in this nineteenth century) in matters wrongly termed "religion,"—especially where sectarian interests are involved,—is fortunately not without such instructive illustration as will serve to keep the thoughtful on their guard. The never-

* Mill makes a remark bearing on this point ("Utilitarianism," p. 44):—"Unhappily it [the moral faculty] is also susceptible, by a sufficient use of the external sanctions [*i.e.*, eternal punishment, &c.] and of the force of early impressions, of being cultivated in almost any direction; so that there is hardly anything so absurd, or so mischievous, that it may not, by means of these influences be made to act on the human mind with all the authority of conscience."

† The other author, a friend formerly largely associated in the thought and preparation of the scheme of this essay, and who had an equal (perhaps greater) share in the development of the main principle, has reasons for remaining anonymous for the present. The work and study connected with the essay has extended, from time to time, over some three years. This is mentioned to avoid any idea of the publication having been entered on prematurely.

‡ The fact that religious belief is a mere unrealised dead letter (or profession) with the majority, so as to have no practical effect on their lives, is well illustrated by Mill in his celebrated essay on "Liberty." At the same time, is it not a sad thought, in view of the enormous number of diverse creeds in the world (each sect maintaining its own to be the only *true* one), to contemplate the means for the brain-poisoning of youth that the prevalence of so much error must afford? It would not be of so much consequence if these doctrines were not instilled before the intellect is sufficiently developed to distinguish truth from error. For if ignorance be a great evil, how much greater must be the scourge of false doctrine! For it is indeed far more difficult to *un*-learn than to learn. Moreover, does not the prevalence of so many diverse creeds in the world afford a signal illustration of the recklessness of invention on the one side, and of credulity on the other?

to-be-forgotten spectacle (only a few years since) of the Cardinals—men who had passed through Universities—sitting in numbers in solemn Council on the Infallibility of the Pope, remains a standing warning that there is no fable, however wild and absurd, no superstition, however monstrous and incredible, which, under the guise of "religion," will not gain masses of adherents; and therefore this shows, with incontrovertible logic, how necessary it is to inquire into everything and be on the alert if we would keep clear of error. No one could say that this is not a fair illustrative case, or that the warning it contains in regard to the doctrines of Clericalism may not be as applicable to one country as to another.

One would not desire to prohibit speculation on so-called "religious topics," but let us take especial care that speculations are not at any time made up into a book and taught as *truths*, and above all let us be on our guard that the speculations are not irreconcilable with each other, or directly opposed to the attributes of goodness and justice that are ascribed to the Deity.

Let speculations and scientific inductions be carefully distinguished from each other. While a relic of barbarous tradition tells the degrading narrative of the Fall of Man, inductive science points to the ennobling view of his Rise, thus opening out a practically limitless field for a greater rise in the future, progress in the past being the best guarantee and incentive to progress in the future.

Surely there could be no nobler doctrine than that inculcated by the self-interest or individual happiness morality, viz., that man's interests and happiness lie in the practice of virtue, or that the path of virtue and that of self-interest are identical with each other. What higher incentive could there be to an upright life than this? Those who oppose this doctrine must be prepared to contend [as some superficial people, who imagine they are sharp, do] that virtue or strict integrity is *not* its own reward.* There would seem to be a sort of cringing or slavish disposition to some extent prevalent which thinks that virtue can only be attached to privation and absence of freedom, as if it were thought that the Deity took a pleasure in seeing his creatures practise

* The follower of the morality of self-interest is contented with the reward that virtue brings with it; not looking to an enormous (infinite) reward in the future. He also does his best to lead mankind by teaching them that right conduct is in accordance with self-interest, not to coerce them by a degrading system of terrorism.

a course of conduct that made them miserable.* Instead of ennobling virtue by regarding its practice as the privilege and interest of a free man, there is often rather a tendency to degrade it by identification with the abject "*duty*" of a slave.

The natural or un-sectarian morality (grounded on Natural Science) constitutes the very ideal of liberty, the freedom of contributing to one's happiness. This morality might therefore be termed with equal propriety the morality of liberty; and the very fact of its constituting the perfection of liberty might be viewed as an additional confirming illustration of its truth, in so far as the complete achievement of liberty is justly regarded as one of the last conquests of human progress.

Morality in Relation to Evolution.

If the morality of self-interest be brought under the test of the theory of Evolution, we think that it will not fail to become clearly apparent that the two harmonise in a remarkable manner. For Natural Selection has been recognised to adapt a living being to the conditions of life, and accordingly tends to produce in animals such "instincts" as are adapted to protect them from danger. "Sociability" (by which animals congregate in troops) is one of these instincts. Natural Selection may therefore be said to tend to develop such instincts in animated creatures as to cause them to act in a way conducive to their *interests* (which is the self-interest morality).

It becomes evident, therefore, that in the case of man—if the power of reason (attendant on brain development) be sufficiently augmented—this may largely replace (in regard to conduct) the "instincts" formerly established by the rough drill of Natural Selection. While the lower animals blunder, and Natural Selection corrects their errors by working upon the brain to develop instincts which check the repetition of errors; man, on the other hand, by using his reason aright, may avoid blundering, and thus may emancipate himself, to a great extent, from the rough discipline of Natural Selection.

There is evidently a great difference (in degree) in this respect between man and the lower animals. For self-interest being the guide of conduct, one of the highest

* The animated coffin-like types of humanity, immured in the cloisters of the Jesuits, may serve as instructive illustrations of this principle carried out to an extreme degree.

attainments of knowledge must therefore be *to know one's interests.** It could not therefore be expected that the lower animals would have advanced anything like so far as man in this respect. That most important of interests, "Sociability," which requires some penetration and thought to appreciate its value and consequences beforehand, is where the lower animals notably fail; and it is a significant fact that the higher the animals stand in the scale of intelligence the more do they appreciate the value of sociability. Thus the ant, various mammals, the higher apes, &c., associate in communities, and are known to be distinguished for their exceptional brain development. Man therefore has progressed in proportion as he has discovered the value (interest) of sociability; *i.e.*, he has advanced in the same ratio as he has gained a knowledge of his own interests (all blunders being errors against one's interests).†

It forms a noteworthy confirmation of this to consider the progress of any civilised nation in the past. At first we may observe that the knowledge of self-interest had only developed so far as to cause small communities or tribes to associate together, who, however, were in continual war with neighbouring tribes. If we thence look at the feudal times, then the knowledge of self-interest had spread further, and there was much greater harmony and association; but still the parts of a single nation were in frequent strife and contention. At the present day the harmony has extended itself to whole nations; but still these are occasionally at war: nevertheless the violation of mutual interests here involved is becoming every year more and more clearly seen. Thus we may perceive that the advance in intelligence, by affording a clearer appreciation of self-interest, has always coincided with the development of association,

* This fact may make it cease to be surprising that people may run after the most pernicious sectarian delusions and imagine them to be to their interests.

† As in some respects an instructive illustration of the opposition of selfishness and self-interest, Free Trade might be mentioned. At one time, when intellect was perhaps not quite so highly developed as now, a species of commercial suicide (called by irony "Protection") is known to have been largely practised, by which it was sought to derive benefit at the expense of one's neighbour by taxing his goods. The strangulation of trade and violation of self-interest thus resulting might be compared to the condition of the selfish individual who isolates himself from his neighbours, and who makes no true friends, and, nevertheless, whose intellect is often of so low an order as to be unable to discover the cause of his unhappiness. It is notorious that selfish individuals are generally of inferior intellectual capacity. No one will probably doubt for one moment that selfish persons who isolate themselves, and miss the great benefits of sympathy and friendship, are unhappy. If so, the morality of self-interest (as the opposite of selfishness) must commend itself as an irrefragible truth.

in order to gain the inestimable benefits of co-operation and friendship among mankind.

Mr. Darwin, in his work "The Descent of Man," appears to consider that man (in relation to the principle of Evolution) may be still influenced to a certain extent by some of the more important "instincts" which formerly belonged to a lower state, such as "Sociability" for instance. But it would not seem to follow necessarily from this (and perhaps this would not be essentially implied) that man might not now, by the light of his reason, test these instincts, in order to see whether they are desirable or not. At least it may probably be conceded that it would not be a thing to be wished that man should be dominated by "instinct" without the control of reason, or this would surely be a somewhat low (and undefined) basis on which to rest morality. It becomes only necessary, therefore, to trace an "instinct" [shown to be dependent on Natural Selection] up to its rational basis, in order to see that this is self-interest. This amounts to no more than taking the final step of advancing the undefined "*instinct*" up to its definition. We must not shrink from this through fear of discovering the bogey Selfishness behind it. The worst of this confounding of self-interest with selfishness is that it has caused inquirers to fear reason. It would be a pitiful state of things if we were afraid to look Reason in the face. Morality thus loses all its dignity. While a lower animal may act by such and such an "instinct" ("sociability" for instance) without being able to appreciate the *cause* of the "instinct," man, on the other hand, may be able to define the reasons for it, and even to say beforehand whether a given course of action is desirable or not.

There cannot, we think, be a shadow of a doubt, on analysing the question impartially, that the extraordinary fact of no generally recognised standard of conduct existing—in spite of the immense advance of the other sciences—is mainly due to the mistaking of self-interest for selfishness (its opposite). For it is a notorious fact that the self-interest morality has been driven home by hard logic again and again, by the ablest minds from the Greeks downwards, but its fitness or suitability has escaped appreciation, or the bugbear of Selfishness has always intruded itself and prevented its adoption. Nevertheless, it may be observed that the only escape from selfishness is by recourse to the morality of self-interest. If a man by practising unselfishness earns the immense benefit of the high esteem and friendship of his neighbours, is he to forego this benefit and become

selfish in order to avoid following his interests? What other course would be possible? Herein lies surely the impossibility of escape from the self-interest morality, and (may we not add) the absurdity of the attempt to do so. This unfortunately perverted tendency to exterminate self (owing to the mixing up of selfishness with self-interest) has no doubt tended to stunt and wither some of the best impulses of our nature, viz., those which urge us to earn the praise and esteem of our fellows by good actions. Where, indeed, we might ask, would even love or friendship be without self? Abolish self (in the form of the happiness enjoyed) on each side, and where would be the friendship or the love?

It may be safely concluded that all great systems have a *simple* principle on their basis, and morality makes no exception to this. The turgid or diffuse discussions that one sometimes finds on this question may be doubtless the not unnatural result of the immense difficulties inevitably encountered in wandering from the truth, under the frightening influence of the bugbear of Selfishness. The very ingenuity (sometimes almost desperate) of the attempts made to avoid basing morality on self-interest are surely themselves among the best illustrations of its validity. It is hardly likely that so fundamental a truth could have eluded general recognition, had it not been for this peculiar oversight. Indeed it has been ably argued, by many reasoners of admitted ability, that a man *cannot* act excepting by something which affects his interests, or touches his individuality in some way; for that which does not affect *him* cannot make *him* act (or is not a rational *motive*). Hence it would result that the morality of self-interest (or individual happiness) always *is* —tacitly, or even unconsciously—followed. It only therefore remains to recognise its *fitness*, officially and openly, in order to derive that benefit which attends the appreciation of any great truth.

It might possibly be thought by some that we have criticised unnecessarily some dogmas and (so-called) "moral" precepts, which are sometimes unfortunately taught as part of education. But it should be noticed that truth cannot be effectively illustrated excepting by contrast with error; and it will be sufficiently clear that some of the dogmas and points of doctrine referred to are, beyond question, highly dangerous. Moreover, only a few instances have been selected for analysis, where many might have been noticed; and we have every ground for confidence that a good purpose will be served thereby.

The more the question is examined, the more apparent

will it surely become that the neglect to identify morality with self-interest has caused great evils. It has acted as the strongest discouragement to virtue, by making it appear *against* one's interests, and has given rise to the invention of those pernicious dogmas (above referred to) which are worse than vain attempts at terrorism. If in the general system of education it were invariably taught that the path of virtue, or strict honesty and sobriety, was absolutely in acccordance with self-interest (in fact that virtue is its own reward), and that such practices as intemperance, thieving, or deceit were to be avoided, because they were *against one's interests*,—instead of the absurd statement that they are "wicked" (which only makes them more attractive, from the intangible nature of the reason), there can be no question that immense good would result. In fact it would be doing more than making morality stand upon reason,—its only sure basis.

Responsibility and Physical Causation.

It has been argued by some that from the fact of the original formation of man's character having been determined by causes beyond his control (or because a person is not reponsible for his inherited brain structure), that therefore he cannot be made accountable for his actions. Mill notices this view in his "Utilitarianism," p. 83, viz.: "The Owenite invokes the admitted principle that it is unjust to punish anyone for what he cannot help." But we think it may be made clear that the supposed absence of responsibility under the above conditions is a fallacy, and that in addition to this, the doctrine of strict causal sequence in nature may enable us to arrive at what might be capable of forming a rough basis for a scientific penal code. We will endeavour to point this out in as clear terms as possible.

When any crime is contemplated, the eventuality of punishment is taken into consideration beforehand, and balanced against the direct material gain that would ensue from the crime, the chances of escape being duly allowed for, and it is this balancing process that accompanies the decision of the wrong doer to commit the offence. The additional punishment, consisting in forfeiture of position in society (which would probably be of itself more than sufficient to deter any respectable member) does not of course influence the habitual criminal. If therefore the punishment fixed beforehand by society (*i.e.*, by the penal code) be such that when the criminal has duly allowed for the chances of

escape, the amount of punishment (as a contingency) seems in his judgment to be less than the direct material gain derivable from the crime, then he is led to commit the offence. He therefore, of course, *deserves* the punishment if detected, because this was precisely what he contemplated beforehand, and which entered in as a factor in determining his decision. To remit the punishment would be exactly like remitting afterwards the loss sustained in a lottery which was contemplated as an eventuality beforehand (the injustice of which would, of course, be self-evident). Since crime is committed for the sake of the material gain that attends it, to repeal the punishment would be to offer a reward for wrong doing. The absurdity of society offering a premium for misdemeanours is too evident to need further comment. Indeed, the removal of penalties for crime would precisely resemble (in principle) the cancelling of prizes in an honest contest, the prospect of earning which had induced the competitors to contend.

No doubt the criminal (like the case of the lottery) may miscalculate somewhat beforehand the value of the material gain attendant on an evil action, when balanced against the contingent loss (represented by the punishment), and, doubtless, society is obliged to fix beforehand the punishment somewhat higher than the value of the prospective gain accompanying the misdeed, in order to deter from evil actions. But on this account the criminal is by no means a subject for unmitigated pity. At the very outside (even if this concession were perfectly above suspicion) he could only deserve the relatively insignificant amount of pity due to the *surplus* of punishment over its true contingent value, which society is obliged to put on in order to make dishonesty unprofitable—and the existence of which *surplus* (in the penalties) the criminal has failed to see beforehand, either from imperfect reasoning faculties or a neglected education. He may be compared to a foolish gambler who goes on playing when the value of the chances of the table is calculated against him.

That a principle, mathematical in its nature, underlies the system of punishments, so as to be capable of forming a rough basis to a scientific code, will probably have become tolerably evident from the above considerations. For there is clearly for every crime a certain amount of punishment which is merely the exact equivalent of the material advantage gained by the commission of that crime. The probability of escape must, of course, be allowed for, so that, for instance, when the chance of detection (derivable from

statistics) is in the ratio of one to a hundred, the punishment equivalent to the stealing of as much as a thief could earn by honest work in a day, would be a hundred days' labour. This would be the *minimum* mathematical value of the penalty under the above conditions, and if society did not counteract the advantage gained in the theft by at least this amount of punishment, it would be absolutely offering a reward for stealing. But it is necessary that a flourishing society should do more (or it must fix the penalty somewhat in excess of its true *minimum* value) in order to make the unfair method of attaining definite ends positively disadvantageous, so that it may not be adopted except by members of inferior reasoning power. No doubt special considerations may influence the administration of the code in special cases, but the recognition of a broad or general principle underlying the penalties is not on this account of less value or importance.

It may, perhaps, assist in appreciating that the above principle is a just one (in regard to the *minimum* value of the penalty) to observe that if detection were *certain* (in the case of a sum stolen, for instance), then the mere deprivation of the sum afterwards would be sufficient as a penalty to check thieving (as it would destroy all profit). It must follow logically from this, therefore (on the same principle), that when detection is *not* certain, a fine equal to the chance of escape multiplied by the value of the sum abstracted, would also be a sufficient penalty, because all means of gain would thus be entirely extinguished (and a margin of loss remain in the trouble of abstracting the sum). This is evidently merely an instance of varying the punishment by inflicting fines instead of the equivalent labour.

The above analysis may perhaps serve to make it sufficiently clear that the feelings of responsibility, praise, and blame (originally formed probably as "instincts" through natural selection), have a distinct rational foundation, and are in harmony with the doctrine of strict causal sequence in nature. The penal code may be regarded as merely a more emphatic method of awarding blame, or of teaching people that selfishness is the opposite of self-interest. It may be added that those who are interested in the related question of strict causation in physical events, may be referred to a recent letter by one of the authors in "Nature," May 13th, p. 29, "On a Point Relating to Brain Dynamics." It should be remarked, however, that we have since learnt through Mr. George Romanes ("Nature, May 27th, p. 75), that the mode of reconciliation of the rival views on Free Will *v.*

Necessity suggested in that letter, was very analogous to a means proposed by the late Prof. Clifford in an oral lecture. This independent deduction of the same result by different minds may perhaps be regarded rather as a confirmation of its truth than not. Mr. Romanes, who apparently accepts the reasoning given in the letter (on "Brain Dynamics") "as far as it goes," nevertheless remarks that both there and in Prof. Clifford's lecture, "The Prince of Denmark," responsibility had been omitted; and he seems to hold the view that the feelings of responsibility, praise, and blame, cannot be reconciled with the doctrine of strict physical causation, and suggests at the end of his letter that these feelings may be destitute of any rational basis. The following is the passage by Mr. Romanes:—

"What then, it cannot but be asked, is the psychological explanation of these deeply-rooted feelings of responsibility, praise, and blame, which can never be eradicated by any evidence of their irrationality? To me it appears the only answer is that these feelings have been gradually formed as instincts, which, while undoubtedly of much benefit to the race, are destitute of any rational justification."—("Nature," p. 76).

This is the only point where we would venture to differ with Mr. Romanes (while otherwise fully endorsing his letter). Possibly the above carefully considered conclusions may serve as some help out of this difficulty, which has always been regarded as a formidable one. It would at all events seem to us *à priori* more probable that the function of science should rather be to *explain* the "instincts" developed in man, than to show them to be devoid of rational foundation. Precisely on account of the beneficial light that science may be expected to shed on matters of this kind, does it become all the more difficult to understand the half-expressed repugnance of some to scientific inquiry on subjects of this class—almost as if it were imagined that the discovery of truth was a thing more to be dreaded than the persistence of error.

Conclusion.—Since life is valuable only in proportion to its happiness, or happiness is the object of existence, the struggle for life therefore becomes synonymous with the struggle for happiness, and the practice of conduct favourable to happiness constitutes morality. Just as the life of the individual receives important aid from the community (to whom the individual owes some of the essential conditions for his continued existence); so in the same way the

happiness of the individual is promoted by the community in many important respects.

There cannot be the slightest fear of any principle here by which the pursuit by each individual of his own happiness could take place at the expense of that of the community; for since one of the most important elements in the happiness of the individual is the good will or friendship of his fellow men, he could not be said to be "pursuing his happiness" in forfeiting this; and since any ill-considered attempt to further one's happiness at the expense of others, is instantly felt by them and retaliated upon by the withdrawal of friendship (or the more active reproof of the penal code); this, therefore, by infallibly teaching the individual that the attempted pursuit of happiness *at the expense* of the community is in reality a violation of self-interest (or opposed to his happiness), would infallibly bring his proceedings to a check. Thus a self-righting principle in the moral world (much in analogy to the self-correction of the equilibrium of the moving parts of a system under the great kinetic theory) exists, by which the individual happiness is made alone consistent with the greatest happiness of the greatest number.* In fact, morality is seen to contain that essential element

* How, indeed, could the greatest happiness of the greatest number be secured, if each of the units of that number (the individual) neglected the pursuit of his own happiness? In fact, since the more an individual is happy, the greater is the happiness he inevitably sheds around him; so in this sense it may be considered almost a "duty" for the individual to be happy. It is certain that the highest ideal of morality can never be reached without. It may be observed, that the energy of the automatic correction in the moral world, is always proportional to the disturbance (as in the physical world under the kinetic theory). Thus the more an individual attempts to further his own happiness *at the expense* of others, the more violent is the correction or recoil which acts to diminish his happiness—so keeping him in check. In an analogous way, the more the equilibrium of a gaseous body is disturbed by some molecules acquiring excessive velocities, the greater is the tendency of the surrounding molecules to check the disturbance (or to restore equilibrium). At the same time it is well to keep distinctly in view, that the existence of the community does not, on the whole, tend to diminish individual happiness, but (on the contrary) distinctly to increase it: since the pleasures of sociability are among the greatest. There is, therefore, no restriction of liberty here; for an individual, even if he had his choice, would not wish to exist entirely alone (indeed, solitary confinement is considered one of the worst of punishments). The community increase the happiness of the individual, and (inversely) the happinesss of the individual diffuses itself around him. Thus the conditions for a perfect harmony are seen to exist. It is only the blundering against self-interest, owing to ignorance and false sectarian doctrine, that causes the occasional discord. The knowledge of self-interest—or of the conditions for individual happiness—being the highest achievement of knowledge (as the final end of morality); it is scarcely to be expected that this should be reached yet, though signs of a rapid advance are not wanting. For the progress of science, by enlightening ignorance, will thereby remove the main cause of unhappiness. This may be still further facilitated as the public gradually come to have a juster appreciation of their true friends.

of stability within itself which is the very condition for the existence of self-evolved systems. It will be, of course, understood here that one of the most important elements in the pursuit of individual happiness, is the cultivation of the esteem of one's fellow men by the performance of kind offices, since friendship and sociability are among the mainsprings of individual happiness.

ANALYSES OF BOOKS.

Catalogue of Books and Papers relating to Electricity, Magnetism, the Electric Telegraph, &c., including the Ronalds Library. Compiled by Sir FRANCIS RONALDS, F.R.S. With a Biographical Memoir. Edited by ALFRED J. FROST. London: E. and F. N. Spon.

WE have here a very valuable compilation issued to the world under the auspices of the Society of Telegraph Engineers. After Sir Francis Ronalds retired from the direction of the Kew Observatory, he made the collection of a library of works on Electricity and the allied branches of Science, and the compilation of this Catalogue, which contains 13,000 entries, the object of his life. On his death, in 1873, he bequeathed the library to his brother-in-law, the late Mr. Samuel Carter, with the stipulation that the books should not be dispersed, but preserved so as to be accessible to persons engaged in the study of electrical science. This condition Mr. Carter very wisely fulfilled by handing over the library to the Society of Telegraphic Engineers, represented by a special body of trustees. The Society undertook the publication of the Catalogue and the binding of the books. When this latter task is completed the library will be open not merely to the members of the Society, but, under the necessary regulations, to the public.

It is doubtless forgotten by many that as early as 1816 Ronalds demonstrated, by actual experiment, the possibility of an electric telegraph, and attempted to bring his invention under the notice of the Government. The following communication, which he received from the Secretary of the Admiralty, Mr. Barrow, afterwards Sir John Barrow, and the author of the article "Telegraph" in the seventh edition of the "Encyclopædia Britannica," is a treasure worth preserving:—

"Mr. Barrow presents his compliments to Mr. Ronalds, and acquaints him, with reference to his note of the 3rd inst., that telegraphs of any kind are now wholly unnecessary, and that no other than the one now in use will be adopted.—*Admiralty Office, August* 5, 1816."

The "one now in use" was the old semaphore, useless in the night and in foggy weather. Long afterwards, *at the age of eighty-three*, he received the honour of knighthood!

Heat, a Mode of Motion. By JOHN TYNDALL, D.C.L., LL.D., F.R.S. Sixth Edition. London: Longmans and Co.

WHEN a scientific book—and especially one which has not earned popularity by appealing to unscientific or anti-scientific prejudice—reaches its sixth edition the ground for the reviewer is much narrowed. If he censure, the majority is against him; if he praise, or merely expound, his readers, if men of high culture, call his critique an *Ilias post Homerum*, or, if of a more vulgar stamp, they long to confer upon him that vindictive pinch which in some rural districts is still bestowed upon the bringer of stale news.

The volume before us is not a reprint; it has been modified, improved, and extended. Upon one remark in the Preface we must pause for a moment. Says the author—"Far be it from me to claim for Science a position which would exclude other forms of culture. A distinguished friend of mine may count on an ally in the scientific ranks when he opposes, on behalf of literature, every attempt to render science the intellectual all in all. Ours would be a grey world if illuminated solely by the dry light of the understanding." This is well said; but as there is no earthly prospect of Science ever becoming the "intellectual all in all,"—would not "mental" be the better word?—as there is no possibility of "other forms of culture" being excluded, such concessions seem scarcely needful. But at least every man should have his free choice, and not be forcibly restrained from studying things without he has first spent a serious portion of his life upon words.

In the Preface we find an interesting notice of a work of Carnot's, written and published as far back as 1824, in which he developes the relation between heat and work which has since been independently discovered by Mayer and Joule.

It is somewhat remarkable that whilst the modern view of heat as a mode of motion was generally held by scientific men and philosophers in the seventeenth and the earlier part of the eighteenth centuries,—*e.g.*, Locke, Boyle, Euler, &c.,—the opposite or material theory seems to have gained ground in the first half of the present century, especially in France, where even such a man as Berthollet came forward on behalf of the "received theory of caloric"—a word still used by leader-writers in their often indiscreet "meddling and muddling" in scientific questions.

A very interesting fact is that established by Prof. Frankland, that, by merely condensing the air around it, the pale flame of a spirit-lamp may be rendered luminous, and even smoky, "the oxygen being by the compression rendered too sluggish to effect the complete combustion of the carbon."

We find it mentioned that the liquefaction of chlorine was effected by Northmore as early as 1805, and it is at least probable

that sulphurous acid was liquefied by Monge and Clouet even prior to 1800. Faraday, in 1824, openly admitted that the merit of first liquefying the gases belonged neither to Davy nor to himself.

Touching on the Glacial epoch of geologists, Prof. Tyndall rejects the explanations generally given, such as the reduced radiant power of the sun, the passage of the solar system through a colder region of space, or a re-distribution of land and water, so contrived as to lower the temperature of the globe. He declares that to produce glaciation "we cannot afford to lose an iota of solar action," but want an "improved condenser." How this condensation was effected, nor what it could have been other than a reduction of temperature, we do not find stated.

In treating of the "limits of science" we are gratified to note that Prof. Tyndall takes substantially the same view as Prof. Du Bois-Reymond. He fully admits that, in passing from the region of physics to that of thought, "we meet a problem not only beyond our present powers, but transcending any conceivable expansion of the powers we now possess." Here, then, is a distinct recognition that mental phenomena cannot be explained by the properties of matter and energy. Prof. Tyndall, therefore, cannot belong to the "Kraft-stoff" school, and those who accuse him of materialism would do well to consider with due care the words we have just quoted.

"Heat, a Mode of Motion" must be regarded as a most comprehensive and accurate survey of an important branch of Science, and all the more valuable because not encumbered with that parade of mathematical formulæ which renders so many works on physics unintelligible save to one particular order of minds.

Degeneration. A Chapter on Darwinism. By Professor E. Ray Lankester, F.R.S. London: Macmillan and Co.

This interesting and valuable little work is in substance a discourse delivered by the author at the Sheffield meeting of the British Association. In the introductory portion we meet with the suggestion—humorous, but not the less appropriate—that the Association should plainly state *what* it is seeking to advance. There is scarcely a word in the English language so strangely and vaguely applied—or rather misapplied—as "Science." In vain did Prof. Whewell point out clearly and succinctly the distinction between Science and Art, and between Science and unsystematised knowledge of facts, objects, events. We still hear the British workman use the term as a synonym for pugilism. Persons of culture set our teeth on edge by speaking of the feats

of "Farini's *Zazel*," or of Maskelyne and Cook, or of the "eagle-swoop" of Maraz, as "triumphs of Science."

Prof. Lankester considers that the "most frequent and objectionable misuse of the word 'Science' is that which consists in confounding science with invention—[we think 'industrial art' would have been a happier word]—in applying the term which should be reserved for a particular kind of knowledge to the practical applications of that knowledge. Such things as electric lighting and telegraphs, the steam-engine, gas, and the smoky chimneys of factories, are by a certain school of public teachers, foremost among whom is the late Oxford Professor of Fine Art, persistently ascribed to Science, or gravely pointed out as the pestilential products of a scientific spirit."

Scientific men, in fact, find themselves placed between two fires. Men of business ridicule us for seeking after the cause of the Aurora Borealis, or the laws which govern the distribution of colour in the plumage of a bird or the wing of a butterfly, and consider such knowledge utterly useless and frivolous. On the other hand, poets, parsons, artists, orators, metaphysicians sneer at us because the facts we discover or the generalisations we establish admit of, and sometimes receive, practical applications, possibly of an unæsthetic character. How completely these two kinds of objections refute each other is completely overlooked.

Passing from these introductory considerations to a sketch of the doctrine of organic development as regarded from the Darwinian point of view, the author shows that the action of external forces upon a living being is not necessarily and invariably in one sole direction. Three results are possible: the organism may either remain *in statu quo*, or it may increase in complexity of structure, or, again, it may decrease in complexity of structure. These three possible results Prof. Lankester calls respectively balance, elaboration, and degeneration. The two former of these cases have been fully recognised: it is admitted that certain animal species have remained from remote geological ages unmodified,—a fact which certain writers, misconstruing the very essence of the doctrine of development, have wrested into an argument for the separate, and we might say the desultory, creation of every species. But degeneration, or degradation in structure, the descendant being lower in organisation than its ancestors, has not been admitted by naturalists save in a few exceptional animals,—parasites,—and great credit is due to Dr. Dohrn, of the Naples Aquarium, for applying it in explanation of some animal relationships hitherto perplexing and mysterious. Degeneration is defined as a gradual change of structure in which the organism becomes adapted to less varied and less complex conditions of life. Elaboration, on the other hand, is a gradual structural change in which the organism becomes adapted to more and more varied and complex conditions of existence. "In Elaboration there is a new *expression* of

form, corresponding to new perfection of work in the animal machine. In Degeneration there is *suppression* of form, corresponding to the cessation of work." The author recognises that elaboration of one organ may be, and often is, the accompaniment of degeneration in others. An animal is only to be viewed as an instance of degeneration when it is, as a whole, left in a lower condition than that of its ancestors. Prof. Lankester considers that any new set of conditions which secure the food and the safety of any animal without effort lead as a rule to degeneration.

Some curious instances of degeneration are given. Among others the barnacle, a degraded crustacean, classed by Cuvier and others among molluscs, and only restored to its rightful rank in consequence of the discovery of its juvenile stages of form. The Ascidians the author regards as degenerate Vertebrates, a conclusion justified by the researches of Kowalewsky on their development. They pass through a tadpole state almost identical with that of the common frog, but instead of being elaborated they degenerate. The Convoluta worms, which contain chlorophyll, and have the power of nourishing themselves, like plants, upon the carbonic acid dissolved in the water around them, are also adduced as an instance of degeneration. As the chief causes of such structural degradation the author enumerates parasitism, immobility, vegetative nutrition, and excessive reduction in size. Where these conditions are present degeneration may be suspected, even in the absence of any embryological evidence.

Finally, it is shown that degeneration is not a mere geological question. In vegetable life it plays, as might be expected, a decided part. In language it has long been recognised, and it must be taken into account in anthropology and in social science. Prof. Lankester hints at the possibility of a degeneration in what are at present the leading types of mankind. Who can venture to pronounce such a decay out of the question?

The hypothesis of degeneration is worthy of very careful study, and we must consequently recommend this thoughtful and suggestive treatise to biologists.

Letter of the Commissioner of Agriculture on Sorghum Sugar. Washington: Government Printing-Office.

A PAMPHLET recommending the cultivation of sorghum in the United States as a source of sugar, and giving descriptions and figures of the machinery required for extraction.

Alphabetical Manual of Blowpipe Analysis, showing all Known Methods, Old and New. By Lieut.-Colonel W. A. Ross, F.C.S. (Berlin). London: Trübner and Co.

Four years ago we had the pleasure of examining a work by Col. Ross, entitled "Pyrology, or Fire Chemistry." We could not, in common fairness, pronounce it other than valuable and suggestive, and we felt bound to recommend it to chemists and mineralogists as well deserving practical criticism. We declared that it would be well worth the while of any student possessing the necessary time, patience, and skill, to work through the book and verify the phenomena described. How far the chemical public has condescended to take our advice is doubtful. Had it done so to any appreciable extent we should certainly have read of confirmations of some of the observations made, and certain interesting facts at which the author glances in passing would have been followed up.

Meantime Colonel Ross has not been idle. In the little volume before us he has embodied, in a convenient and portable form, the results of his twenty years' experience in blowpipe analysis. We find here, within the compass of 150 pages, a description of the necessary apparatus and reagents, and of the methods for their application,—both those discovered by the author and those of earlier experimentalists which he has verified.

A curious feature of the work is a process for the quantitative determination of cobalt in ores and furnace-products, based on the colours produced by the oxide when dissolved in vitreous reagents. The mechanical details of the operation, which, as it is remarked, must be conducted with very great care, are not given.

Methods for the detection of some of the rarer metals are not wanting, and here the author frequently resorts to the spectroscopic examination of the pyrocones and pyrochromes which are produced. He has devised for this purpose a small spectroscope which can be worn like a pair of spectacles, thus leaving the hands at liberty. He cautions the beginner never to attempt to learn the reactions of any substance from native minerals, however pure they may be supposed, but always to work upon pure oxides.

A passage which puzzles us, and some scientific friends whose attention we have called to it, is the following:—

"*Chemical Water.* A combustible but not vaporisable compound, composed apparently of hydrogen and oxygen, present in every natural and in almost every artificially prepared oxide. It ignites at apparently red-heat, and burns with an orange pyrochrome, *i.e.*, a non-luminous flame tinged with colour."

The detection of calcium phosphate in the body of a fly is a curious observation. The author remarks that "volatile metals may also be thus detected; for if an ordinary healthy fly be consumed as above, and the resulting bead compared with another

in which a fly poisoned on arsenical paper has been burned, a very marked difference can be observed between the two, even with an ordinary lens." It is quite possible that the number of elements which enter into the systems of plants and animals may prove, on careful examination, much more numerous than has been hitherto supposed.

A paragraph headed "Diamonds, Artificial, to make" is capable of being misunderstood. The substance produced, consisting exclusively of lime and boric acid, has little chemical analogy with the diamond. The author states that he has discovered the colouring principle of the sapphire, and can now make stones, chiefly of alumina, a deep blue colour without using any colouring oxide whatever. What this colouring principle is the reader is not informed.

To those chemists—unfortunately too few, in England at least—who study the reactions of substances in the dry way, as well as to mineralogists, geologists, mining engineers, &c., this book may be safely recommended, and from its portable character it will prove a useful travelling companion on exploring expeditions.

We wish Colonel Ross continued success in that department of chemistry to which he has devoted himself with such ardour and perseverance, and a wider appreciation than has hitherto been his lot.

Journal of the Society of Telegraph Engineers. Vol. ix., No. 32. May, 1880.

This number contains a summary of the present position of electric lighting on the Jablochkoff system. The author considers that if we take it for granted that the question of electric lighting does not progress more rapidly than the other great discoveries and inventions of the century, one may fairly expect that it will, within a very reasonable time, become of general and every-day use.

The desirability of getting rid of the term "candle-power," in the measurement of light, was suggested.

Prof. Hughes read a paper on some effects produced by the immersion of iron and steel wire in acidulated water. Whatever the quality of the metal, or the nature and proportions of the acid, the wire is rendered brittle, whilst similar treatment produces no such effects upon copper and brass. The author adopts the view suggested by Prof. W. Chandler Roberts, that the result is due to the absorption of hydrogen.

Results of Astronomical Observations made at the Melbourne Observatory in the Years 1871 *to* 1875 *inclusive.* Under the direction of R. L. J. ELLERY, Government Astronomer to the Colony of Victoria. Melbourne: J. Ferres.

WE have here a collection of observations which are of course valuable data for the astronomer, but which are incapable of being criticised. The volume opens with a notice of the exact position of the Observatory, upon which follow a list of the staff and an account of the instruments.

The American Naturalist. May, 1880.

AMONG the valuable matter found in this excellent journal we are particularly struck with an article by J. S. Lippincott, entitled "The Critics of Evolution." We have never seen a happier or more complete exposure and refutation of the calumnies and personal imputations with which some authors and orators have sought to encounter the doctrine of Evolution, especially in that phase commonly known as Darwinism. If anything could make such men as Joseph Cook, C. Hodge, and F. O. Morris feel intensely ashamed of themselves it would be a careful perusal of Mr. Lippincott's statements. He shows that, so far from having undertaken an atheistic propagandism, as the Rev. F. O. Morris has dared to assert,* Mr, Darwin admits a Divine agency and Divine supervision in forming and peopling the world. It is perfectly true that in the earlier days of the Darwinian controversy the new theory—as it was supposed—was eagerly accepted by the so-called free-thinkers, and was advocated from heterodox platforms and in heterodox journals, a championship which official "free-thought" now repents of, and is very little likely to continue. But wherefore was Evolution thus welcomed? Simply because ignorant or jealous critics had pronounced it atheistic. Mr. Darwin's great sin, in the eyes of the modern Pharisees, was that he had shed some light on God's ways of working! It is strange, but instructive, to learn that "of all the younger brood of naturalists whom Agassiz educated, every one —Morse, Shaler, Verrill, Niles, Hyatt, Scudder, Putnam, even his own son—has accepted Evolution."

* "I do my little best or worst to shake their faith." *See* Journal of Science, 1878, p. 468.

CORRESPONDENCE.

CURIOUS PHENOMENON IN A FROG.

To the Editor of The Journal of Science.

SIR,—Being on an occasion in my greenhouse I observed a cat playing with a small frog—patting it with *velvet* paw, with the evident purpose, for its own amusement, of making it jump: this continued some time. Whilst absorbed in the contemplation of a plant my attention was arrested by a very peculiar noise—a kind of suppressed shriek, seemingly expressive of pain. I looked about to ascertain the cause: the cat was still playing with the frog, and from the frog I found the sound proceeded. When the cat patted the frog the cry was emitted, evidently from an excitation of fear, or from weariness excited by the forced activity induced by the cat's undesired attentions. I was the more surprised at the sound because I was under the impression that all the vocal expressions of frogs was the croak. Naturalists are silent on this phenomenon. On the gardener coming into the house I called his attention to the peculiarity of the cry emitted by the frog. He treated the matter as a very commonplace incident, and said it was common with frogs when in terror; that he had frequently heard it, and that it was always uttered by frogs when pursued by a snake or a viper.—I am, &c.,

S. B.

[Our correspondent's gardener is perfectly correct; frogs do utter shrieks if pursued by serpents. We cannot at the moment refer to any text-book of natural history in which this fact is mentioned.—ED. J. S.]

ROOKS SETTLING.

To the Editor of the Journal of Science.

SIR,—In my neighbourhood are many rooks. Observing them, I saw a rook (they generally, if not always, fly with the wind)

about to settle, when it made a semicircle before alighting. I thought this movement was exceptional, but, continuing my observations, I found that all the rooks made a half circle *against the wind* before settling. I thought it a curious instinct. Repeated observations have confirmed me in the idea that it is their universal habit, occasioned, I suppose, by the necessity of breaking the impetus of the momentum acquired by their downward flight on the wind. The change in direction is probably occasioned by the interstices to be observed in the spreaded wing of a rook, disabling them by any other means to arrest the acquired velocity. The turn made is always against the wind, and even then on settling they appear to strike the ground with a heavy thud. Doubtless was the ground reached in direct downward flight, the weight of the bird and the inability of control—occasioned, most likely, by the interstices between the feathers of the wings—would cause fracture or other serious inconvenience.—I am, &c.,

S. B.

ORIGIN OF THE PERCEPTION OF NUMBER.

To the Editor of the Journal of Science.

Sir,—A little boy, the son of a friend of mine living at Aylesbury, seeing three rooks perched on the branch of a tree, exclaimed, "Quo, quo, quo!" It struck me that these words explain the manner in which the number of objects is apprehended by young children and by the lower animals.—I am, &c.

C. S.

NOTES.

Mr. J. W. Redhouse, in a communication to the Royal Society of Literature, combats the ordinary theory that the Aryan race of mankind originated in the Pamir highlands of Central Asia, spreading thence in a north-westerly direction into Europe, and south-easterly into India. He considers that the Polar regions, which at one time possessed a tropical temperature, were the original home of man.

Signor Beccari has observed that the visits of a certain ant (*Pheidola Javana ?*) seem essential to the health, and even the existence, of certain plants of the genus *Myrmecodia*, from Borneo.

According to a communication made to the Linnean Society, on behalf of Mrs. Bunbury, of Western Australia, it appears that the once common flowers of that colony are becoming rapidly scarce in the pasture lands, and that it is even difficult to propagate them by culture.

The "Revue Internationale des Sciences Biologiques" gives an extensive memoir by Dr. Carl Hoberland, on "Infanticide among Ancient and Modern Nations." He traces the origin of this custom to the difficulty of subsistence, the sacrifice being in the outset urged by the male parent, and opposed or reluctantly submitted to by the mother. (We observe a parallel case among certain of the lower animals, where the young are often destroyed by the father, and are defended against him and concealed by the mother.)

The invention of the diaphote, if all that is alleged concerning its powers proves correct, recals the magic mirrors in which, according to tradition, mediæval necromancers were able to show their clients persons, objects, and events in distant countries.

According to M. Corder, the groups of shooting stars proceeding from different centres have distinctive characters as regards colouration.

The Chinese consider the use of cows' milk, as an article of human diet, unnatural and immoral. It does not appear that this opinion is based on the comparative indigestibility of the milk of ruminant animals.

Dr. Manson has observed that in persons affected by *Filariæ* the blood is comparatively free from these parasites during the

day, but swarms with them at night, especially during those hours when mosquitoes bite most freely. He has also described the life-history of the *Filaria* during its development in the body of the mosquito.

Mr. F. Galton, in a paper read before the Anthropological Society, described a curious psychological phenomenon. About one in every thirty adult males, or fifteen females, whenever they think of numerals, see them in a vivid mental picture, and each number always occupies the same relative position in their field of view.

The following incident was communicated to the "Popular Science Monthly" by a valued correspondent:—"A bull dog and a Newfoundland came into collision in Federal Street. The Newfoundland took to his heels for safety, and was closely pursued. Seeing that he was likely to be overtaken he caught up a bit of dirt from the street, and at the critical moment dropped it as if it were something of value he was obliged to give up. The *ruse* succeeded; for the bull-dog stopped to pick up the supposed tit-bit, and the Newfoundland escaped. The disgust manifested by the vicious brute when he found how he had been outwitted is said to have been very comical."

An "Anti-Vivisectionist Conference" was held in Edinburgh on the 22nd of May, under the presidency of the Earl of Kintore. Balaam's ass was brought forward as evidence in favour of the agitators.

The "Medical Press" reports a fatal case of hydrophobia resulting from the bite of a cat. No light is thrown upon the manner in which the cat became affected.

According to the "Medical Press" the death-rate in St. Petersburg is 59 per 1000, or more than three times that of London.

With reference to Dr. Croll's "eccentricity theory" of glaciation, Mr. A. R. Wallace writes to the "Geological Magazine" to show that, independent of ocean currents, Europe and North America are subject to different climatic conditions, which explain why the ice-fields should extend farther south in the western continent. The author is about to publish an important modification of Dr. Croll's theory, which we shall await with much interest.

Mr. P. M. Bose, in a valuable paper on Extinct Carnivora, communicated to the "Geological Magazine," shows that, starting from *Arctocyon*, the most primitive Carnivora known, there are two divergent series, one comprising *Palæonictis*, *Amphicyon*, and *Cynodon*, and the other *Proviverra*, *Hyænodon*, *Pterodon*, *Amblectonus*, *Oxyæna*, and probably also *Synoplotherium*, *Mesonyx*, *Patriofelis*, and *Sinopa*. The former series approach, in the form of their teeth, the typical Carnivora of which they were

doubtless the ancestors. The second series formed an exceptional group, of which *Hyænodon* was the last and most highly organised form.

M. Ch. Richet has laid before the Academy of Sciences an account of researches on the action of alkaline and acid mediums upon the life of Crustaceans. He finds that such liquids are not poisonous in the direct ratio of their acidity and alkalinity. Nitric acid is five times more poisonous than sulphuric, and twenty-five times more poisonous than acetic and tartaric acids, for equal weights. Ammonia is, in equal weights, thirty times more poisonous than baryta, and fifteen times more poisonous than soda, and even more deadly than strychnine. As all these substances, if injected into the circulatory system, would prove fatal, the difference is probably due to the degree in which they are absorbed.

M. Viallanes, writing in the "Comptes Rendus," demonstrates that the heart of insects is at first a simple tube open merely at its two extremities. As long as there are no lateral orifices the heart is completely arterial. The author has also indicated the mode of the formation of the lateral orifices and of the pericardic sinus.

M. Thibaut finds that the production of urea in the animal system is not exclusively confined to the liver, but extends in a slight degree through the whole organism.

The "Bulletin de la Société Botanique de France" records a case of morbid alcoholic fermentation observed in the roots of apple-trees in Normandy. No yeast-cells or other microphytes were found in the affected roots.

We perceive with regret that the practice of stocking uninhabited islands with goats and rabbits still continues. The consequence is the destruction of the native flora, and, secondarily, of the fauna also.

Dr. W. K. Parker, F.R.S., has communicated to the Royal Society some very important researches on the structure and development of the skull in the Batrachia. Concerning the geographical distribution of frogs, he remarks that there is a sort of *facies* or character about the allied types of any great geographical region which indicates that certain external characters repeat themselves in different parts of the world. The European and Indian regions yield the highest kinds; Australia and South America the lowest and most generalised.

Mr. J. Norman Lockyer, F.R.S., has laid before the Royal Society a further note on the spectrum of carbon. The additional phenomena described are a blue line with a wave-length of 4266, a set of blue flutings from 4215 to 4151, and another set of ultra-violet flutings from 3885 to 3843. The blue flutings

correspond to the lowest temperature, the violet flutings to an intermediate, and the blue line to the highest temperature. The blue line doubtless represents the most simple molecular grouping.

Mr. W. H. Preece has communicated to the Royal Society a paper on some "Thermal Effects of Electric Currents." The facts elicited are the extreme rapidity with which fine wires acquire and lose their increased temperatures, and the excessive sensibility to linear expansion which fine wires of high resistance evince.

Dr. W. J. Russell, F.R.S., and S. West, M.B., have communicated to the Royal Society a memoir on the relation of the urea to the total nitrogen of the urine in disease. The authors conclude that the chemistry of the urine remains the same in disease as in health, the urea forming 90 per cent of the total nitrogen.

The same authors have also contributed a paper on the determination of the "vital nitrogen" in man. They give the average as 8 grms. = 17·5 grms., or 260 grains of urea.

Mr. J. Costerns has examined the action of saline solutions upon the life of vegetable protoplasm. He observes that the cellules of the red beet-root, if the air has free access, are injuriously affected by solutions of common salt and saltpetre. In presence of very small quantities of air these same liquids prolong the life of the cellules.—*Archives Néerlandaises.*

M. J. A. Roorda Smit concludes that in South Africa the diamond is found in a primitive gangue which is of volcanic origin and has experienced merely secondary modifications. The mines are extinct volcanic craters, and the diamonds have been formed at the expense of organic matter under the joint influence of great pressure and strong heat.—*Archives Néerlandaises.*

We have the pleasure of announcing that the New York Anti-Vivisection Bill has fallen through.

Mr. T. Wrigley, of Timberhurst, near Bury, has bequeathed £10,000 to Owens College.

M. Selzer communicates to the Imperial Academy of Sciences at Vienna that he estimates the optic fibres in the human eye at 438,000, and the retinal cones at 3,360,000.

The "Pharmaceutische Central Halle" recommends the following mixture for the destruction of parasites on plants:—

Boracic acid	10 parts.
Salicylic acid	5 ,,
Rectified spirit	20 ,,
Water	200 ,,

The liquid is applied to the plants by means of a spray-producer.

M. Ekunina ("Journal für Praktische Chemie") has investigated the acid reaction which appears in the animal tissues after death, and finds it due to a decomposition of the juices produced by *Schizomycetes*. Volatile fatty acids first appear, generated by the incipient decomposition of the albumen, soon followed by the two forms of lactic acid derived from glycogen. The more carbo-hydrates are present in any tissue the longer its acid reaction remains after death. In from twenty to forty hours the lactic acids disappear, and are succeeded by succinic acid. Finally the reaction becomes alkaline, in consequence of the ammonia formed by the decomposing albumen.

Prof. Huxley, in his lecture on the "Coming of Age of the Origin of Species," delivered at the Royal Institution, says—"It was gravely maintained and taught that the end of every geological epoch was signalised by a cataclysm, by which every living thing on the globe was swept away, to be replaced by a brand-new creation when the world was restored to quietness. . . . I may be wrong, but I doubt if at the present time there is a single responsible representative of these opinions left." In a work entitled "Outlines of Geology and Geological Notes of Ireland, by Mr. W. Hughes, and which has reached its third edition, the ultra-catastrophist view is stated in its most unmitigated form. The author declares that "this earth was subjected to repeated changes, that thousands of years intervened between them, and that each completely destroyed all animal and vegetable life." The progress of sound Science has not been so rapid as Prof. Huxley supposes.

Dr. G. Thin has laid before the Royal Society a memoir on *Bacterium fœtidum*, an organism associated with profuse sweating from the soles of the feet. The exudation in question has no offensive smell as it escapes from the skin, but acquires its characteristic odour when absorbed by the stocking. It is not pure sweat, but contains an admixture of blood-serum, and has an alkaline reaction. The author describes and figures the stages of development of the *Bacterium*.

Mr. J. B. Hannay communicates to the Royal Society a memoir on the state of fluids at their critical temperatures. He contends that the difference between the fluid and the gaseous states is not entirely dependent upon the length of the mean free path, but also upon the mean velocity of the molecule.

According to a memoir submitted to the Academy of Sciences by M. Marangoni, the swim-bladder is the organ which regulates the migrations of fishes. Those species which frequent shallow and warm waters, and are always found at the bottom, are without swim-bladder, and do not migrate. Those which have a swim-bladder generally inhabit deep waters, but rise to the surface to spawn. Fishes do not rise spontaneously, and have to

struggle with their fins against the influence of their swim-bladder. This organ renders them instable, both as to level and position. This, the author considers, helps to render them agile, as the most active of terrestrial animals are those which have the least stability.

G. D. Liveing, F.R.S., and J. Dewar, F.R.S., communicate to the Royal Society a memoir on the history of the carbon spectrum, in reply to Mr. Lockyer's paper on the same subject, read before the Society April 29th, 1880. In a subsequent paper, on the spectra of the compounds of carbon with hydrogen and nitrogen, the same authors remark—"As we have now demonstrated the utterly unsatisfactory character of the crucial experiment on the strength of which Mr. Lockyer condemns in so sweeping a manner our conclusions, it follows that the whole fabric of his argument is utterly futile, and it seems unnecessary to add any further comments.

J. B. Ramsay, F.R.S.E., has forwarded to the Royal Society a paper on the solubility of solids in gases. He concludes that a gas must have a certain density before it will act as a solvent, and when its volume is increased to more than twice its liquid volume its solvent action is almost destroyed. The volume remaining the same, the solvent power rises with the temperature.

R. C. Rowe, F.I.C., Cambridge, has communicated to the Royal Society a simplification of Abel's theorem.

Mr. W. Crookes, F.R.S., has communicated to the Royal Society, in the form of a letter to the Secretary, Prof. Stokes, a condensed summary of the evidence in proof of the existence of a fourth state of matter. In conclusion he says, "That which we call matter is nothing more than the effect upon our senses of the movements of molecules. The space covered by the motion of molecules has no more right to be called matter than the air traversed by a rifle bullet has to be called lead. From this point of view, then, matter is but a mode of motion; at the absolute zero of temperature the inter-molecular movement would stop, and, although *something* retaining the properties of inertia and weight would remain, *matter*, as we know it, would cease to exist."

According to Mr. A. Wilcocks, the shadows thrown by the planet Venus are distinguished from those thrown by the sun and the moon by their sharpness, the penumbra being totally wanting. This is due to the fact that to our eyes Venus is merely a luminous point, whilst the light of the sun and of the moon emanates from broad disks.—*Proc. Amer. Phil. Soc.*, xvii., p. 705.